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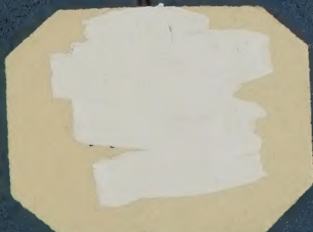
FOURTH
ANNUAL REPORT
OF THE
SCIENTIFIC AND INDUSTRIAL
RESEARCH COUNCIL
OF ALBERTA
1923

PRINTED BY ORDER OF THE LEGISLATIVE ASSEMBLY



EDMONTON:
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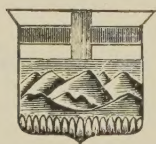


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ORGANIZATION

The Scientific and Industrial Research Council of Alberta, formed in January, 1921, carries on its work in co-operation with the University of Alberta.

The personnel of the Council at the present time is as follows:

HON. HERBERT GREENFIELD, Premier of Alberta, Chairman.

H. M. TORY, President, University of Alberta.

J. T. STIRLING, Chief Inspector of Mines, Province of Alberta.

J. A. ALLAN, Geologist.

N. C. PITCHER, Mining Engineer.

R. W. BOYLE, Dean, Faculty of Applied Science, University of Alberta.

EDGAR STANSFIELD, Honorary Secretary, University of Alberta.

Requests for information and reports should be addressed to the Honorary Secretary, Industrial Research Department, University of Alberta, Edmonton, Alberta.

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UNIVERSITY OF ALBERTA,

EDMONTON, ALBERTA,

FEBRUARY 29TH, 1924.

HON. HERBERT GREENFIELD,
Premier of Alberta,
Edmonton, Alta.


Sir:—

Under instructions from the Scientific and Industrial Research Council of Alberta, I herewith submit their Fourth Annual Report. This covers the work done under their direction during the year ending December 31st, 1923.

Respectfully submitted,

EDGAR STANSFIELD,

Honorary Secretary.



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FOURTH ANNUAL REPORT OF THE SCIENTIFIC AND INDUSTRIAL RESEARCH COUNCIL OF ALBERTA

PERSONNEL AND MEETINGS OF COUNCIL

Five meetings of the Council were held during the year. At the fourth meeting R. W. Boyle, M.A., Ph.D., Dean of the Faculty of Applied Science at the University of Alberta, was added to the Council. Otherwise the personnel remained unchanged during the year. This is as given below:—

HON. HERBERT GREENFIELD, Premier of Alberta, Chairman;
H. M. TORY, President, University of Alberta;
J. T. STIRLING, Chief Inspector of Mines, Province of Alberta;
J. A. ALLAN, Geologist, University of Alberta;
N. C. PITCHER, Mining Engineer, University of Alberta;
R. W. BOYLE, Dean, Faculty of Applied Science, University of Alberta;
EDGAR STANSFIELD, Honorary Secretary.

STAFF

The following changes have been made during the year:—

W. P. Campbell commenced work as Fuel Analyst on April 30th.

W. L. McDonald commenced work as Assistant Engineer in the Fuels Division on October 17th.

W. G. Jewitt commenced work as Assistant Engineer in the Road Materials Division on December 6th.

The permanent staff on December 31st, 1923, was as follows:—

EDGAR STANSFIELD, Research Engineer, *Fuels*;
K. A. CLARK, Research Engineer, *Road Materials*;
R. T. HOLLIES, Assistant Research Engineer, *Fuels*;
S. M. BLAIR, Assistant Engineer, *Road Materials*;
W. P. CAMPBELL, *Fuel Analyst*;
W. L. McDONALD, Assistant Engineer, *Fuels*;
W. G. JEWITT, Assistant Engineer, *Road Materials*;
J. B. COGHILL, Recording Secretary;
H. D. MOON, Laboratory Assistant.

In addition to the above, Professors J. A. Allan and N. C. Pitcher, of the University of Alberta, Members of the Council, are in permanent charge of the Council's research work in Geology and in Mining Engineering, respectively.

Other members of the University Staff have assisted from time to time; notably Prof. R. S. L. Wilson devoted considerable time during the year to work for the Council on the timber resources of the province, and Prof. C. A. Robb made a special study of the combustion of coal for the generation of power in the province. Prof. A. E. Cameron carried out a number of washing tests on coal. Mr. H. A. McMillan, Engineer-in-Charge of the power plant, was of great assistance in the erection and operation of the bituminous sand separation plant, and N. H. Atkinson, Demonstrator in Mining Engineering, during the early months of the year worked on coal briquetting tests.

In the Geological Division, Dr. Allan was assisted by the following temporary members of the staff, both in the field work and in the preparation of the report:—

DR. R. L. RUTHERFORD, Field Geologist in charge of survey work in the Foothills belt between the North Saskatchewan river and the Macleod river. He is also co-author of the geological report on this area.

W. G. JEWITT, Field Assistant on the survey party.

VERA V. STOVER, acted as Geological Office Assistant for the first half of the year, and edited and looked after the distribution of the Fourth Annual Report on the Mineral Resources.

MARGARET FIFE was stenographer for the Division during the last three months of the year.

In addition to the above, G. C. Haworth and W. E. de Mille held the positions of Cook and Packer respectively on the Foothills party, and F. M. Ethridge was temporarily employed as Draughtsman in the preparation of maps.

ORGANIZATION

In the organization of the University of Alberta the staff of the Research Council constitutes the Industrial Research Department, and the Research Council's laboratories are referred to as the Industrial Research Laboratories.

In the organization of the Provincial Government the work of the Research Council is attached to the Department of the Provincial Secretary.

LABORATORIES AND EQUIPMENT

The laboratory accommodation and facilities available at the University for the work of the Council have been described in previous reports. During the year slight additions were made to the work bench accommodation. The apparatus for the fusion of ash was set up in the assay laboratory of the Department of Mining Engineering, and the bituminous sand separation plant was housed in the basement of the University Power Plant building.

The principal items of new equipment acquired during the year are as follows:—Melters furnace, with blower and motor; four recording thermometers, two recording hygrometers, potentiometer, meter prover, two electric furnaces, a McClary heater, and an oil emulsion dehydrator, acquired by purchase; a viscosimeter for pitch, hot air calorimeter, air-drying apparatus for coal, and many small

pieces of apparatus, designed and largely constructed at the University. The bituminous sand plant was designed and erected at the University, but many items, such as motor, pump, shafting, pulleys, gears, valves, etc., and accessory equipment, were purchased. Also equipment for road tests was purchased. A gas calorimeter and electric combustion furnace and equipment, also scales and screens were supplied by the Mines Branch for work carried out for them. Additions have been made to the library during the year.

FUELS

The work of the year on fuels was mainly a continuation of that of previous years. Four carload samples of coal were received and tested. It has been found that four such samples are as many as can be handled during the year without unduly crowding out other work.

Part of every carload sample of coal was screened over perforated plate screens, and part over bar screens. The products through the different screens were separately collected, weighed and analyzed. The information gained gives a comparison between the two types of screens, and also the relative amounts of the different coals occurring in the run of mine coal, and the distribution of the ash through the different sizes. This last point is important in connection both with the marketing of sized coal and in connection with possible purification of the coal. Stored samples of coal were also re-screened at the end of the storage periods in order to determine the physical disintegration undergone.

Storage tests have been continued, and two-year tests completed on seven different coals during the year. The method of reporting the results has been changed to avoid confusion from excessive detail and to bring out conclusions.

A new code is in course of preparation for testing carload samples of coal at the University Power Plant, in order to determine their suitability for the generation of steam. It is hoped that the usefulness of this work will be materially increased thereby. A committee has conferred with the principal combustion engineers of the province in an endeavor to correlate and conserve their efforts towards improved methods of burning the lower grade Alberta coals under boilers. A summary of the report of this committee is given in the appendix. The full report is to be multi-graphed, and will be supplied at cost to those interested.

Progress was made during the year in the working out of suitable methods for testing domestic heaters. A number of prolonged tests were made, but no series of tests was completed on any additional heater during the year. This work has now reached the point where rapid progress may be expected.

No carbonization tests were made during the year. It is recognized that carbonization of the non-coking coals, the particular problem taken up here, is bound up with that of briquetting, and it has been deemed advisable to concentrate for the present on the latter problem. The briquetting press was in active use during the spring and fall of the year, and 159 batches of briquettes were

made. Thirty-three of these were made from carbonized lignite, and the rest from bituminous coal. The binders tested included two samples of coal tar pitch, one lignite pitch, and three asphalts, as well as a considerable number of compound binders. At the close of the year it was deemed advisable to concentrate attention for a while on a study of the physical properties of the different available binders. It is hoped in this way to put the art of briquetting on a more scientific basis.

Some further work has been done with regard to methods for reducing the ash content of certain high ash coals. It has not yet been found possible to commence regular work along this line, though it is recognized that the problem is a very pressing one in some districts.

Smithy tests were carried out on several coals during the year. One of these was found to be very good for the purpose, and another quite satisfactory, whilst a third could be used for simple work. These results confirm the idea that continued importation of Pennsylvania coal into this province is an absurdity.

A graduate student of the University is engaged in the study of the clinkering properties of the ash of typical coals. This work is being conducted under the direction of the staff of the Council, and with apparatus supplied by the Council. The results are not yet ready for publication.

In addition to the four carload samples of coal referred to above, the District Inspectors of Mines have taken small channel samples to represent the regular output of the mines they visit. These samples in the past were analyzed by Mr. J. A. Kelso, Provincial Analyst, but in May of this year the work was transferred to the Research Council's laboratories. Samples of dust are also taken from certain mines by these inspectors and submitted for chemical and physical analysis. In all, 224 such coal and dust samples were received during the year, but analysis had only been completed on 180 of them at the end of the year.

Methods of handling, analyzing and reporting the samples were improved during the year, particularly with regard to a standard method for air-drying. It is hoped by means of the analytical work on the above samples to accumulate comparable and accurate analyses of the output of most of the producing mines of the province within the next year or two. A compilation of analyses has been begun, but it is not now expected that this will be completed during 1924.

A detailed account of much of the above work on fuels is given as an appendix.

GEOLOGY

The geological work for the Council was carried on in conjunction with the Department of Geology of the University. The demand for information on various phases of the mineral resources of Alberta increased as indicated by the correspondence. During the year 530 letters were received, and 651 written. At least one-half of these letters requested geological information on various parts of this province that was not yet available. Many requests

were made on oil possibilities, and several requested direction for competent geological advice. Other requests, besides those on coal and bituminous sand, varied widely in character. These requests referred to clays, clay products, limes, salt, sodium and aluminium sulphates, peat, timber, fish resources, gem stones (including three on diamond possibilities), resins, trails and pleasure resorts.

About 200 specimens and samples were received by J. A. Allan, and were reported on free of charge. In certain cases samples were forwarded to the Industrial Laboratories for chemical analysis.

About four months were spent in the field by J. A. Allan in various parts of the province. Besides supervising the Foothills survey, the rock core from drilling operations for salt at Waterways was determined, and the data compiled at the well site. Accompanied by N. C. Pitcher and A. E. Cameron, a trip was made up Clearwater river from its mouth to the Cascades near the eastern boundary of the province. A short summary of the activities of the Geology Division is appended in this report, but full details of the continuation of the Foothills survey make up Report No. 9, "Geology along the Blackstone, Brazeau and Pembina Rivers, in the Foothills Belt, Alberta."

Samples and specimens were obtained for the Alberta exhibit to be sent to the British Empire Exhibition. Details of this exhibit are given below. Considerable time was given to the compilation of data for the geological map of Alberta now being prepared. The base map has been completed, and the contour lines and geological information are being added to the base map. An endeavor is being made to complete this map in 1924.

MUSEUM

One section of the Geological Museum has been set aside for an exhibit of Alberta minerals, and manufactured products from these minerals. During the year the Med-Alta Stoneware Company of Medicine Hat added to their exhibit a number of pieces of pottery of high grade. Other additions included aluminium sulphate from Smoky river, contributed by Mr. L. E. Drummond, and high refractory clay from Athabaska river, 75 miles below McMurray.

In order to preserve a permanent record of the formations drilled through in Salt Well No. 2 at Waterways on the Clearwater, about 550 feet of the rock core was shipped to the Geological Museum, and parts of this core are being placed in the exhibit. The entire rock core of Salt Well No. 1, drilled by the Provincial Government at McMurray to a depth of 685 feet, was previously arranged in open exhibit cases, so that the records of these two wells are available for further examination and comparison in the form of the rock cores. A complete suite of drill samples, taken every five feet to a depth of over 3,000 feet from the well drilled by the West Regent Oil and Gas Company at Monitor, has also been added to the museum collections.

MINERAL EXHIBIT FOR THE BRITISH EMPIRE EXHIBITION

In June, J. T. Stirling, Chief Inspector of Mines, requested J. A. Allan to supervise the preparation of a mineral exhibit for the British Empire Exhibition, to be held in England in 1924. With the assistance and co-operation of N. C. Pitcher, K. A. Clark and some of the Mine Inspectors, an exhibit was prepared and forwarded to the Canadian Exhibition Commission at Ottawa, as the Alberta exhibit was included in the Dominion exhibit. The exhibit included the following: Semi-anthracite coal from the Canmore Coal Co., Ltd., Mine No. 2, Stewart Seam; semi-anthracite coal from the Canmore Coal Co., Ltd., Mine No. 2, Carey Seam; bituminous coal from the Mountain Park Coal Co., Ltd., Mine No. 282; sub-bituminous coal from the Bighorn & Saunders Creek Collieries, Ltd., Mine No. 388; sub-bituminous coal from the McLeod River Hard Coal Co., Ltd., Mine No. 846; sub-bituminous coal from the Lethbridge Coal Co., Ltd., Mine No. 676; bituminous sand from McMurray, Alberta; crude petroleum from the No. 1 well (Okotoks field, Alberta) of the Alberta Southern Oil Co.; crude petroleum from the No. 1 well (Okotoks field, Alberta) of the Southern Alberta Oils, Ltd.; gasoline, manufactured from natural gas, Royalite well, Okotoks field, Alberta; pottery from the Alberta Clay Products Co., Ltd., Medicine Hat, Alberta—4" sewer pipe, 6" sewer pipe, 8" sewer pipe, 8½" by 8½" by 24" flue lining, 4" quarter bend, 9" wall coupling, 6" agricultural drain tile, 4" by 12" by 12" hollow building tile, and 8" by 12" by 12" hollow building tile.

SALT WELL AT WATERWAYS

Two wells have been drilled 300 miles north of Edmonton by the Provincial Government to prove the possible occurrence of rock salt in that portion of Alberta. No. 1 well was drilled at McMurray, and details of the results have been given by J. A. Allan in the Second Annual Report on the Mineral Resources of Alberta (1920).

As the Alberta and Great Waterways Railway now terminates at Waterways on the Clearwater river, six miles east of McMurray, No. 2 well was drilled close to the "end of steel" to determine if the salt beds extended east to this point. This well site was chosen by J. A. Allan at the junction of Deep creek and Clearwater river within a hundred yards of the railway. Drilling began in October, 1922, and the well was completed in September, 1923, at a depth of 785 feet, when the pre-Cambrian granite was reached. The details of the results are given by J. A. Allan in another part of this report.

COAL AREAS OF ALBERTA

In all compilations of coal analyses, and in other references to the coals of the province, it is convenient to arrange the coals in groups. In publications of both the Federal Mines Branch and the Scientific & Industrial Research Council of Alberta, coals have in the past been classified according to the provincial mine inspection areas, which are based largely on geological features. This classi-

fication is unfortunate in several respects for this purpose, and it was therefore decided to divide those parts of the province from which coal is produced into areas based on the geology, so that coals with similar characteristics might be classed together and the analyses of such coals grouped for publication.

A map has been prepared by J. A. Allan, and is included in this report, which outlines 36 coal areas. The positions and boundaries of these areas include the producing mines, and are based on the three coal-bearing formations usually known as the Kootenay, Belly River, and Edmonton. This map is in four colours, on a scale of 30 miles to 1 inch. Officials of the Dominion Department of Mines have assisted with criticisms and suggestions, so that it is hoped that this subdivision will be generally accepted until such time as, by reason of the acquisition of new geological information and the opening up of new coal areas, a revision becomes necessary.

ROAD MATERIALS

The year's work of the Road Materials Division included the construction and operation of a bituminous sand separation plant, the construction of an experimental stretch of bituminized earth road, a preliminary study of the bituminous sand deposits, and laboratory tests on the extracted bitumen.

The bituminous sand separation plant was designed as an expansion to a semi-commercial scale of the process previously developed and operated on a laboratory scale. The plant built was capable of handling half a ton of bituminous sand per hour, and was successfully employed to treat some eighty-five tons of the sands.

Most of the bitumen produced in the plant was used for testing in practice the method developed in the laboratory for the stabilization of the soils of the province with such bitumen. The aim of the experiments was to produce an economical earth road that would be serviceable not only in dry but also in wet weather. An experimental stretch of 450 feet of bituminized earth road was constructed on the Fort Saskatchewan Trail, just beyond the Edmonton city limits. Details of the two practical experiments referred to above are given in the appendix.

Work was begun, during the year, on two additional phases of the general problem of the utilization of the bituminous sands. A short visit was made to the deposits in preparation for a more systematic study of the bituminous sand occurrences which it is proposed to make in 1924. Laboratory tests were also commenced on the bitumen, in order to determine the quantity and quality of the refined oil products that could be manufactured therefrom.

FOREST PRODUCTS

A questionnaire was sent to coal mine operators in every mining district of the province asking for certain detailed information concerning mine timbering practice and preferences. Most of the districts were visited later, and a compilation made of the results of the enquiries with a view to determining the most promising line of detailed studies. Answers respecting species used, usage of fire-

killed timber, peeling, seasoning and effects of fungus, make it evident that practice is greatly diversified, and emphasize the necessity of finding solutions to many important problems.

A series of tests was started on lodgepole booms and props. These tests were planned to take into account differences due to use of timber, peeled and unpeeled; green and seasoned; variations in humidity, temperature and circulation conditions underground; and period of time in service. Structural tests at all stages will be completed.

Further details of this branch of the work are given in the appendix.

ACKNOWLEDGMENTS

The McGillivray Creek Coal & Coke Co., Ltd., the West Canadian Collieries, Ltd., the Bighorn & Saunders Creek Collieries, Ltd., and the Tofield Coal Co., Ltd., have each contributed a carload of coal during the year. The Council again desires to express their appreciation of the continued support they are receiving from the operators in this and other ways.

Acknowledgment is also made to the following firms who contributed materials required for investigations in progress: The Philadelphia Quartz Co., four drums of silicate of soda; the Imperial Oil Co., samples of refined and crude oil; the Pacific Mills, Ltd., barrel of sulphite liquor; the Austin Chemical Co., sample of sulphite pitch; and Robeson, Inc., sample of lignone. Moreover the Manitoba Bridge & Iron Works supplied a large shaking screen at below cost.

Mr. John Shanks, President of the Western Canada Coal Operators Association, secured the co-operation and interest of mine operators in the Province for the work of the Committee on Alberta Forest Products. Messrs. J. and A. Dunn, of the Great West Coal Co., Ltd., provided facilities for timber testing at the mine. Courtesies were extended by many operators to our visiting representative.

FUELS

By N. C. PITCHER, E. STANSFIELD, R. T. HOLLIES, W. P. CAMPBELL,
W. L. McDONALD and N. H. ATKINSON.

COALS TESTED

Four carload samples of run of mine coal were received during the year for screening, storage, boiler and other tests. The coal was in each case donated by the mine operator. A list of these coals, classified under their respective areas, follows:—

Crowsnest Area:—

McGillivray Creek Coal & Coke Co., Ltd., Coleman, Alta.
West Canadian Collieries, Ltd., Blairmore, Alta.

Saunders Area:—

Bighorn & Saunders Creek Collieries, Ltd., Saunders, Alta.

Tofield Area:—

Tofield Coal Co., Ltd., Tofield, Alta.

SAMPLING

The methods discussed in earlier reports have been followed without change during the year.

ANALYSES

Two changes were made during the year in the methods of analysis employed. These changes concern the air-drying of all coals, and the determination of the volatile matter in sub-bituminous and lignitic coals. Furthermore all the analytical methods employed in the laboratory are in turn receiving very careful study, but this work is not yet ready for report. In the method of air-drying previously employed the coal was exposed to the air of the laboratory. In the winter, when the humidity in the laboratory was very low, the coal thus exposed dried out far more completely than it did in the summer, when the humidity was relatively high. In the new method, the coal is air-dried in a regulated atmosphere that will be the same, winter and summer. More closely concordant results are now being obtained than was possible earlier. The apparatus employed is described later, under the heading of water in coal. The method for determining volatile matter in sub-bituminous and lignitic coal was described on page 18 of last year's report. The method has been continued, and found satisfactory. The temperature of the pre-heat muffle furnace, however, has been raised from $725^{\circ}\text{C}.\pm 25^{\circ}$ to $800^{\circ}\text{C}.\pm 25^{\circ}$. The results obtained since this alteration are still comparable with those previously obtained, but the increased temperature avoids even the occasional loss of a determination by sparking during the subsequent treatment at full heat.

SCREENING

The work described in the three previous annual reports was continued during 1923 with the same equipment as before. The new screen referred to below has not yet been used for any of this work. The results obtained, with regard to the amount present of the different sizes and to the ash content of these sizes, for each of the four carload samples tested, are this year expressed in a new and more useful form. For purposes of comparison, the results obtained in previous years have been recalculated where necessary, and are also included in the following tables.

Table I. gives the screened sizes (diameter of circular perforations) used in screening for lump, egg, nut, pea and dust coal. It also gives the percentages of these sizes found in each consignment of run of mine coal as delivered in the laboratory.

TABLE I.—PERCENTAGE OF SIZES IN RUN OF MINE COAL.

Name of Size.....	Lump	Egg	Nut	Pea	Dust
Through .....	....	3"	1 ½"	¾"	¼"
Screen Sizes					
Over	3"	1 ½"	¾"	¼"	....
COAL.					
McGillivray Creek	11	8	10	26	45
Greenhill	8	12	11	29	40
Mountain Park	11	8	6	22	53
Cadomin	14	16	10	24	36
Pocahontas	3	6	6	20	65
Blue Diamond, 1921	1	5	6	26	62
Blue Diamond, 1922	4	8	11	27	50
Saunders Creek	52	15	10	13	10
Foothills	48	17	12	15	8
Monarch	59	19	9	8	5
Big Valley	57	26	10	4	3
Pembina	44	20	11	16	9
Dobell	59	24	8	6	3
Tofield	57	20	9	9	5
Twin City	45	30	10	11	4

Table II. gives a comparison of the ash contents of the different sizes of each coal. The ash content in each size is compared with the calculated average content of all the sizes taken at 100. Thus, if a certain coal contains 8% ash in the lump, 7% in the egg, 9% in the nut, 14% in the pea, and 18% in the dust, and has a calculated average content of 10% ash in the whole consignment; then the relative ash contents of the sizes, where the average is taken as 100, are 80, 70, 90, 140 and 180, respectively.

TABLE II.—COMPARISON OF ASH CONTENT IN DIFFERENT SIZES OF COAL.

Name of Size.....	Lump	Egg	Nut	Pea	Dust
COAL.					
McGillivray Creek	93	116	108	101	96
Greenhill	66	116	115	112	89
Mountain Park	73	129	120	112	94
Cadomin	71	105	118	100	104
Pocahontas	73	129	130	147	83
Blue Diamond, 1921	104	125	137	116	87
Blue Diamond, 1922	95	120	129	103	89
Saunders Creek	106	78	72	85	148
Foothills	93	113	102	102	139
Monarch	102	105	91	95	80
Big Valley	84	112	137	118	151
Pembina	95	92	80	95	....
Dobell	100	105	117	129	....
Tofield	96	96	91	97	129
Twin City	111	104	144	143	....

Table III. gives the percentages of the total ash of the coal found in each size. This table is based on the relative percentage of each size, and the ash content of the coal of that size.

TABLE III.—PERCENTAGE OF TOTAL ASH FOUND IN EACH SIZE.

Name of Size	Lump	Egg	Nut	Pea	Dust
COAL.					
McGillivray Creek	10	9	11	26	43
Greenhill	5	14	13	32	37
Mountain Park	8	10	7	25	50
Cadomin	10	17	12	24	38
Pocahontas	2	8	8	29	54
Blue Diamond, 1921	1	6	8	30	54
Blue Diamond, 1922	4	10	14	28	44
Saunders Creek	55	12	7	11	15
Foothills	44	19	12	15	11
Monarch	60	20	8	8	4
Big Valley	48	29	14	5	4
Tofield	56	20	8	9	6

A study of this last table shows that with domestic coals where there is a large percentage of the bigger sizes, hand picking of these sizes is the obvious method of ash reduction in deliveries, as over 60% of the total ash is found in the lump and egg. The reverse is the case with the bituminous coals, so the purification of the pea and dust is the obvious treatment for best results, as over 60% of the total ash is here found in those sizes.

Table IV. gives equivalency results, as in previous years. These are based on screening tests with run of mine coal, and show the bar screen spacings which must be employed to give the same results as those obtained with plate screens having circular perforations. The table gives the results obtained, averaged by districts for the coals tested. Figures for the Crowsnest and Saunders areas are given for the first time this year. The results given for the Tofield area have been modified by further results obtained during the year. The figures for the other areas remain unchanged.

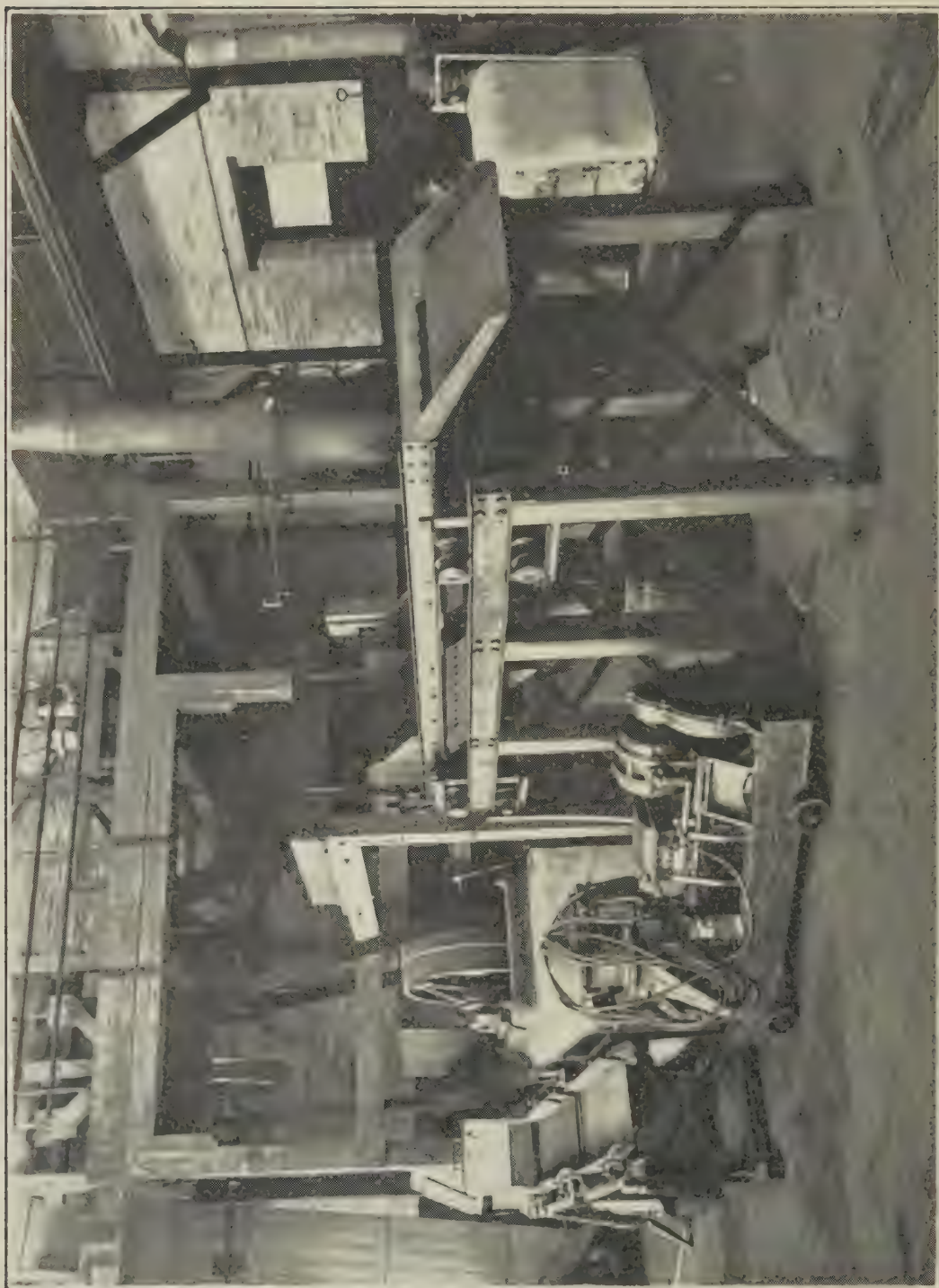


Figure 1.—Shaking Screens and Sampler-Crusher.

TABLE IV.—EQUIVALENT SPACING FOR BAR SCREENS FOR THE
COAL AREAS NAMED.

Measurements in sixteenths of an inch

Diameter of Circular Perforations	3"	2"	1½"	1"	¾"	¼"
AREA.						
Crowsnest	24	16	12	8	6	3
Mountain Park	29	16	12	8	6	3
Brule	28	16	12	8	6	3
Saunders	25	20	16	12	8	3
Coalspur	28	16	12	8	6	3
Drumheller	26	18	14	9	7	3
Big Valley	25	18	12	8	6	3
Pembina	32	21	16	11	8	3
Tofield	26	17	14	10	7	3
Edmonton	33	....	12	....	8	3

A large shaking screen (see Figure 1) of the Jacobsen and Schraeder pattern, built by the Manitoba Bridge and Iron Works, who donated a large part of the expense of its manufacture, has been added to the equipment of the coal testing laboratory. This screen will give several sizes of products simultaneously, such as lump, egg, nut, pea, and dust sizes, without necessitating the changing of plates or bars. Large quantities of coal can be screened in a few minutes, making possible a saving of time in conducting screening tests. The new screen, shown in the centre of the plate, has a total screen area of 42 square feet, as compared with 8 square feet in the old screen shown on the left. The plate also shows the Sturtevant sampler-crusher used for crushing and reducing all samples.

STORAGE

The study of the effect of weathering on coals in storage has been continued as described on page 20, Third Annual Report (Report No. 8), and no new methods have been introduced during the year. Four new coals were placed in storage during the year, and storage tests were completed on seven coals first stored during 1921. The list of samples retested after various periods of storage follows:—

Domestic Coals: 8 samples after one month, 15 after 6 months, 30 after 12 months, and 36 after 24 months storage. The coals tested were from Pembina, Foothills, Monarch, Big Valley and Saunders Creek.

Bituminous Coals: 2 after one month, 2 after 6 months, 1 after 12 months, and 4 after 24 months storage. The coals tested were from Pocahontas, Mountain Park, Cadomin, Blue Diamond, Greenhill, and McGillivray Creek.

Reconsideration has been given this year to the method of expressing the results of storage tests. In previous years the percentage reduction of quantity of each size after storage has been stated, but no indication has been given as to how complete the disintegration has been. Thus lump coal may disintegrate principally to egg and nut coals or almost completely to pea and dust.

The economic loss is obviously far less in the first case, although the percentage of the lumps which had disintegrated might be the same in both cases. The mere statement as to size loss is thus misleading, but a complete statement showing the full screen analysis of each sample after storage would be so big and cumbersome as to be almost valueless. The method which has been adopted this year for compiling the results is that of giving an arbitrary value to each size of coal. Thus, if the value of domestic lump is taken as 100, the following give the values assigned to other sizes: egg, 80; nut slack, 40. These values are employed as follows:

If 100 pounds of lump coal after storage shows 80 pounds of lump, 5 pounds of egg, and 15 pounds of nut slack, then the relative value of the coal has dropped from 100 to 90 by reason of its disintegration.

The values taken above are necessarily arbitrary: thus, the relative value of the lump and finer coals varies with the type of coal; and also, with the same coal, varies with the distance from the pit head. The above values were chosen after consideration of the current prices of a number of coals at the mine and at Winnipeg. Any results based on these values can only be taken as giving a relative indication of the extent of disintegration of the different coals. The actual results obtained have all been compiled, and will be supplied, if desired, to the mine operators concerned.

Table V. gives in concise form a summary of the results obtained with coals classified according to the normal moisture content as mined. It should be noted that this is only a provisional table based on comparatively few results; that storage in large piles or shed storage would show less disintegration than the figures given, which are based on small scale tests in open storage; and that only physical changes in the coal are considered.

TABLE V.—COMPARATIVE DISINTEGRATION LOSSES ON STORAGE OF DOMESTIC COALS.

Normal Moisture Content in Coal as Mined, %	Comparative Distintegration Loss, One Year's Open Storage, %
5 to 10	1 to 5
10 " 20	5 " 15
20 " 30	15 " 30

The following notes summarize the observations thus far made:

(1) The loss in heat value of the coal during storage is small, but the amount has not yet been determined.

(2) The tendency for lumps to disintegrate increases with increase in the normal moisture content of the coal as mined.

(3) The surface of a pile weathers first, and the fines produced protect the coal underneath. This is clearly shown by inspection of the samples and by the slight loss occurring during the second year of storage if the coal is undisturbed.

(4) Coal distintegrates less in either pit or shed storage than when exposed to the weather in the open.

Attention is again called to the advisability of carrying out larger scale work to supplement the preliminary small scale work which has so far been undertaken.

DOMESTIC FURNACES

Figure 2 shows the present equipment of furnaces, as set up for testing. From left to right they are: a Gurney hot-water furnace; Allan hot-water furnace; hot-water jacket heater; Sunshine hot-air furnace; and, on the extreme right, a McClary heater.

The work of testing was conducted along the lines described in the last report, and no further changes were made during the year. The equipment, however, was increased by the purchase of four recording thermometers and a water meter, and the construction of an automatic sampler and sensitive draft gauges. A new air calorimeter was also built. This is similar to the one shown on page 23 of the 1922 report, but of larger capacity. The inside diameter was increased from 18" to 27", the number of baffles decreased, and the angle of rotation between successive baffles changed from 90° to 60°. These changes materially reduced the obstruction to the upflow of hot air through the calorimeter. There was some trouble in keeping in adjustment the high-range recording thermometers used in the smoke stack. A duplex recording pyrometer was therefore ordered at the end of the year, which should overcome this difficulty. The equipment now on hand is sufficient to permit simultaneous tests on a hot-water and on a hot-air furnace. Thanks to the recording instruments, prolonged tests can be made with a single shift of staff.

The work of the year was as follows: Six tests with a total duration of 687 hours on the Gurney hot-water furnace; six tests with a total duration of 304 hours on the Sunshine hot-air furnace, and one run of 45 days duration on the McClary heater with Pratt hopper arch attachment. This work includes tests on three special appliances which are claimed to be fuel savers. Tests were conducted as described in the 1922 report. A summary of the experiments, and comments on the results, are given below.

Gurney Hot-Water Furnace

The experiments with this furnace were confined to tests of two furnace accessories: first, the Little Wonder Fuel Saver & Gas Burner; and, second, the Robb Coal Carburetor.

The former appliance was essentially a check damper, and as such was found to be simple and efficient. A further claim has been made that its use results in the improved combustion of the furnace gases. No improvement was noted, however, beyond that due to its action as a check damper.

The tests on the Robb Coal Carburetor are not yet completed, but the results obtained indicate improvement in combustion, as evidenced by the study of the flue gas analyses. On the whole, the flue gas analyses with this furnace, though fairly satisfactory, show room for improvement, and this feature is to be studied further.

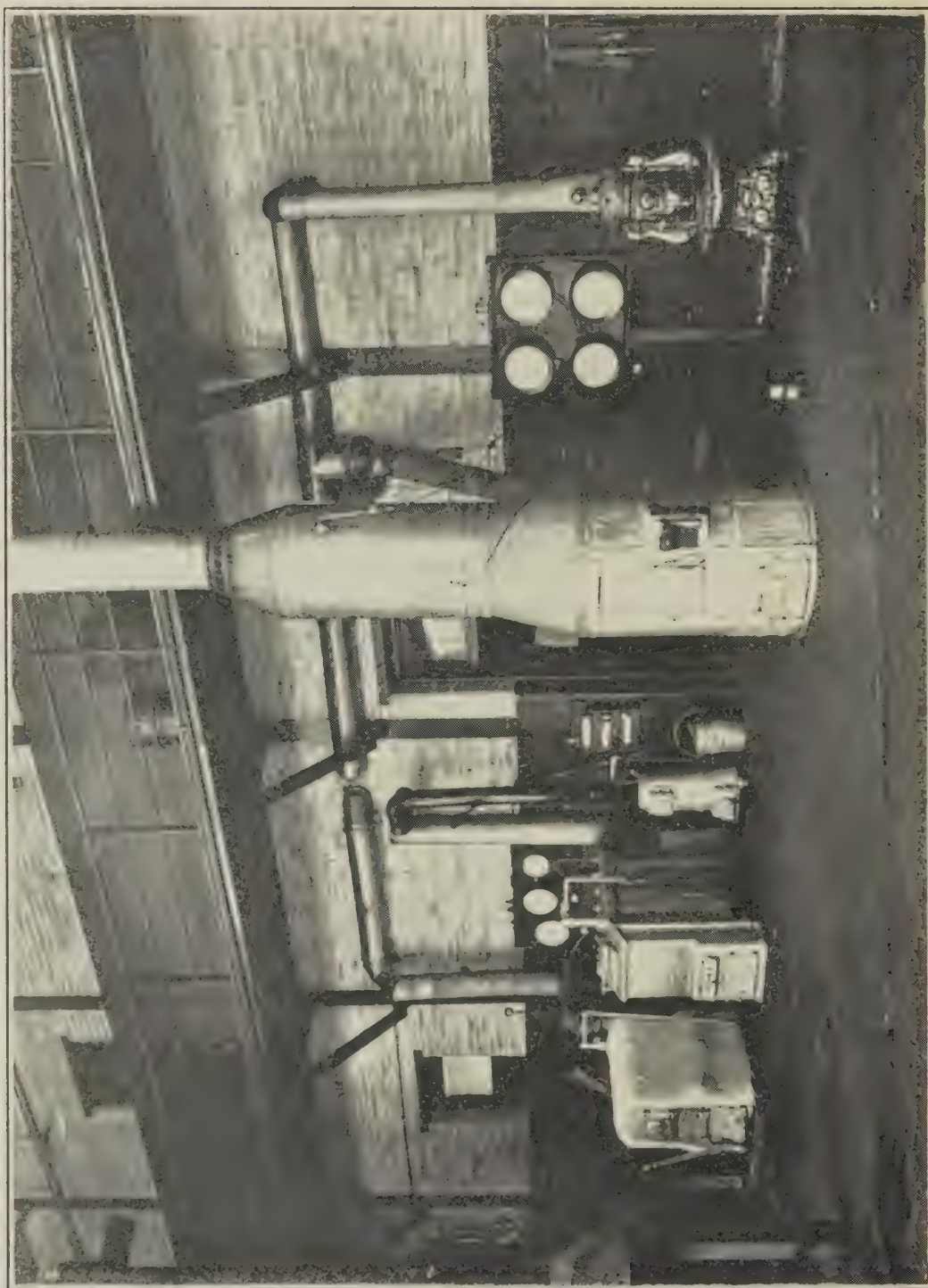


Figure 2.—Domestic Heaters.

Sunshine Hot-Air Furnace

A series of tests were run after the installation of the new air calorimeters to determine the worth of the air-blast ring supplied around the inside of the fire pot. A summary of the results obtained follows:—The blast ring materially assists the proper combustion of the coal by supplying air all around the fire pot just above the fire where it is needed for the combustion of the volatile matter. Moreover, with its use, the fire picks up quicker after firing, and can then be more thoroughly checked, in which condition less air is drawn through the fire and more is drawn over it. Analyses show less oxygen in the flue gases when the blast ring is in use.

Incidentally it might be stated that the $\frac{3}{4}$ " grate spacing supplied with the furnace is too wide for the non-coking domestic coals so far used. The loss of unburned coal to the ash pit when the fire is cleaned is thus too large. Other tests have shown that $\frac{1}{4}$ " to $\frac{3}{8}$ " grate spacing works best with such coals. The three separate rocking grates supplied work well, especially when the alternate method of firing is used.

*McClary "Belle Oak" Heater, No. 36, with Pratt Patent
Hopper Arch Attached*

This attachment consists essentially of a vertical plate of asbestos composition which divides the fire pot into left and right compartments. This plate reaches from near the top of the furnace to within 6" of the grates. The right hand compartment is used as a fuel hopper, whilst the left hand side functions as usual. The grate under the hopper is fixed, and covered with a sloping plate to deflect the fuel from the hopper on the right to the combustion area on the left. In use, the fire burns as usual on the left, although this fire is somewhat maintained by fresh coal feeding from the hopper. In addition, the volatile matter from the coal in the hopper is distilled out and ignited by the glowing fire on the left. Later in the operation, the fire gradually rises through the reserve coal in the hopper.

A continuous run of 45 days duration was made. During the week the grate was shaken two or three times daily, and clinker was taken out of the fire side twice a day. An incandescent fire was maintained on this side of the grate almost continuously, with an average coal consumption of 33 pounds per day. Usually the fire burned from Saturday noon until Monday morning without attendance.

No measurements were made with this heater, but the laboratory assistant who ran it reported simplicity and steadiness of operation with the smaller sizes of domestic coal.

Miscellaneous

Some time was spent determining the variations, from wall to wall, in the temperature of a furnace flue. These temperatures were measured by means of a high-range mercury thermometer with a small bulb. The evidence collected indicated that, if the bulb of a recording thermometer was placed so that it extended horizontally

from the circumference to the center of the flue, it would approximately register the true average temperature of the flue gases.

SMITHY TESTS

These tests, commenced in March, 1922, as described in the Third Annual Report, have been carried out on five Alberta coals studied during the year, and a check test was made on coal said to be George's Creek (Pennsylvania) smithy coal. The smithy tests are carried out by the University blacksmith under the supervision of R. T. Hollies. The welded pieces made are examined in the testing machine of the Department of Civil Engineering under the direction of Professor R. S. L. Wilson. Before making the tests, the blacksmith uses the coal in question for his regular work until thoroughly familiar with its qualities. The tests made are: (1) Heat test on the time required to bring a standard piece of $1\frac{1}{4}$ " rod up to cherry heat; (2) two lap welds on 3" by $\frac{1}{2}$ " wrought iron; (3) two butt welds, $\frac{7}{8}$ " wrought iron rod on to 3" by $\frac{1}{2}$ " flat wrought iron; (4) two lap welds on $\frac{3}{4}$ " octagon steel; (5) making cold chisel from $\frac{3}{4}$ " steel. George's Creek Pennsylvania smithy coal was tested as above at the beginning of the series of tests, and also again later in the series. These tests are taken for comparison with those on the Alberta coals.

Table VI. gives some of the principal results obtained during these tests. The fifth Alberta coal, a high-moisture domestic coal, was found to be quite useless for even simple welding operations.

TABLE VI.—RESULTS OF SMITHY TESTS

Test	Time Required for Test	Yield Point of Test Piece	Failure Point of Test Piece	Failure of Weld
Lap Weld, iron:	minutes	lbs. per sq. in.	lbs. per sq. in.	
McGillivray Creek	15	31,200	45,500	None
Greenhill	21	36,800	48,800	None
Saunders Creek	24	32,200	44,350	Partial
Big Valley	31	31,480	45,820	None
Pennsylvania (1)	22	31,780	40,000	None
Pennsylvania (2)	18	32,500	45,400	None
Unwelded bar .....	....	29,340	46,280	....
Butt Weld, iron:	minutes	lbs.	lbs.	
McGillivray Creek	34	....	22,910	Yes
Greenhill	27	18,300	24,390	Yes
Saunders Creek	40	....	17,800	Yes
Big Valley*	36	....	....	....
Pennsylvania (1)	34	22,310	25,600	Yes
Pennsylvania (2)	23	17,000	27,490	None
Lap Weld, steel:	minutes		lbs. per sq. in.	
McGillivray Creek†	17	....	....	....
Greenhill	22	....	103,000	None
Saunders Creek**	13	....	....	None
Big Valley* .....	....	....	....	....
Pennsylvania (1)	26	....	86,000	None
Pennsylvania (2)	15	....	94,100	None
Unwelded bar .....	....	....	95,500	....

*Weld unsuccessful.

†Test piece burned whilst welding.

**Test piece broke in machine, due to faulty grip.

Summary of Results

McGillivray Creek.—About 36 lbs. of coal were burned, and the fire was cleaned twice. This is a very good smithy coal: clean, easy to handle, little trouble with ash and clinker, and burns with a reasonably short flame.

Greenhill.—About 44 lbs. of coal were burned during test, and the fire was cleaned three times. This is a good smithy coal: little clinker, clean fire, with a short flame which causes but little inconvenience to the blacksmith.

Saunders Creek.—About 83 lbs. of coal were burned, and the fire cleaned three times. This coal can be used for simple welding with safety, but could not be depended upon for large or difficult welds. It burns with a long, hot flame, which causes inconvenience to the blacksmith.

Big Valley.—About 83 lbs. of coal were burned, and the fire cleaned twice. Not considered dependable for smithy work, although a couple of simple welds were made successfully. Burns with a long flame.

George's Creek, Pa.—36 lbs. were burned in the first test, March, 1922, and 28 lbs. in the second, run January, 1924. The fire was cleaned three times in each test. A very good smithy coal, burning with a short flame. The shorter times taken by the blacksmith during the second test were due to his increased familiarity with the work to be done.

BOILER TRIALS

In this report no boiler tests are published, these tests having been temporarily discontinued. It has been found advisable to adopt a new code for testing Alberta coals: a code which will be more suitable for the wide range in varieties which are being submitted for trial; and which will, as far as possible, with the equipment and settings at our disposal, enable us to obtain results of a more uniform nature for comparison of values. Hereafter greater emphasis will be laid on recommendations and suggestions as to means of obtaining better evaporation and greater ease of handling.

It is pointed out that the results previously obtained will not be comparable with those obtained under the new set of test conditions, and therefore no comparisons should be made between the results published in the past and those published in future reports.

Boiler tests may be divided into two classes:—(1) Tests of comparative steam-raising qualities of different coals under examination with set conditions of boiler and furnace; (2) tests of the comparative efficiency of different boilers and settings for a certain grade of coal.

In either case, the test is conducted in the same way. The boiler and furnace is supplied with a known quantity of fuel, the amount of steam generated is measured, and, in complete tests, the amount of heat furnished by the coal and expended in evaporating the water is determined, together with the various heat losses which occur.

The object of the boiler trials conducted at the University of Alberta is to compare the behaviour and usefulness for steam-raising purposes of the various samples of coal supplied. In carrying out the trials, two objects are in view: firstly, to determine the amount of water evaporated per pound of coal under conditions allowed by the settings of the boilers; and, secondly, to form an opinion as to the behaviour of the coal, the amount of labor required to work it in the fire, and its general suitability for steam raising purposes, as shown by freedom from trouble arising from clinker, ash, smoke, etc.

In order to make a fair comparison of the evaporative power of different coals, it is desirable not only to keep the running conditions as uniform as possible during the whole of the test of each coal, but also to arrange the tests so that every sample may have the same chance of developing its maximum evaporative effect. The first condition is an easy one to obtain, but to obtain the second it would be necessary to make a complete series of trials with each coal at various rates of combustion in the same boiler, and this series would then need to be repeated with boilers and furnaces having other designs and settings till the most favorable set of conditions for best results for each coal had been found. The expenditure of time, money and coal necessary prohibits at present such a series of tests being carried out.

Higher efficiencies for many of the coals tested could have been obtained if it had been feasible to make changes in grate bars, furnace, fittings, brickwork, etc., with a view of suiting the boiler and furnace to the peculiarities of each different coal. This, however, was impossible, and it has seemed better to retain the same settings, etc., throughout, even at the risk of showing the performance of some coals at a disadvantage. These conditions will continue throughout the series of tests made, until we are able to undertake the more ambitious programme of changing boiler settings, etc., for each different coal.

The new code for conducting tests will enable us to obtain results which are more nearly comparable, but these results should not be used as an absolute standard of the relative merits of the coals for steam-raising purposes. It is pointed out, however, that the same caution must be exercised in comparing any sets of boiler tests conducted in commercial plants or in most testing stations, as in few, if any, cases are extensive alterations in furnace design made to suit the different coals under test.

BRIQUETTING

The briquetting equipment was installed and ready for use by December, 1922, and was briefly described in the 1922 report. Figure 3 shows the mixing machine in which small batches of coal and binder can be mixed and heated ready for the press. The mixing is done by two blades, rotating in opposite directions and at different speeds. This mixer is steam-jacketted, and steam can also be blown into the mixture if desired. Figure 4 shows the same mixer tipped for discharge. The material can be further mixed in the vertical mixer, or fluxer, situated above the press. This fluxer is also steam-jacketted, and provided with steam jets for blowing

steam into the mix. Steam at 90 pounds pressure is available for heating the mixer and fluxer. Figure 5 gives a general view of the press and the fluxer. Figure 6 gives the plan of the press and fluxer, and Figure 7 a sectional elevation. Figure 8 shows in diagrammatic form four positions of the plungers during the cycle of making and ejecting a briquette.

In making briquettes, the coal is crushed to a suitable size, a batch weighed out, transferred to the mixer, and heated. Usually 18 pounds of coal are taken for each test run. The binder is also weighed out, melted, and poured into the mixer, and the temperature and moisture content of the mix regulated as desired. Usually two or three minutes is found to be sufficient time to complete the mixing, but this time varies with the temperature and therefore the fluidity of the binder. From the mixer the batch is transferred to the fluxer, from which it is allowed to run into the feed hopper of the press. As the rear plunger is drawn back, some of the material in the hopper falls into the die box. Here it is caught and squeezed between the two plungers, and finally ejected from the die box by the rear plunger, which has a longer travel than the front one and only makes half as many strokes per minute. The briquettes fall onto a moving belt, are discharged at the front, collected in a box, and tested.

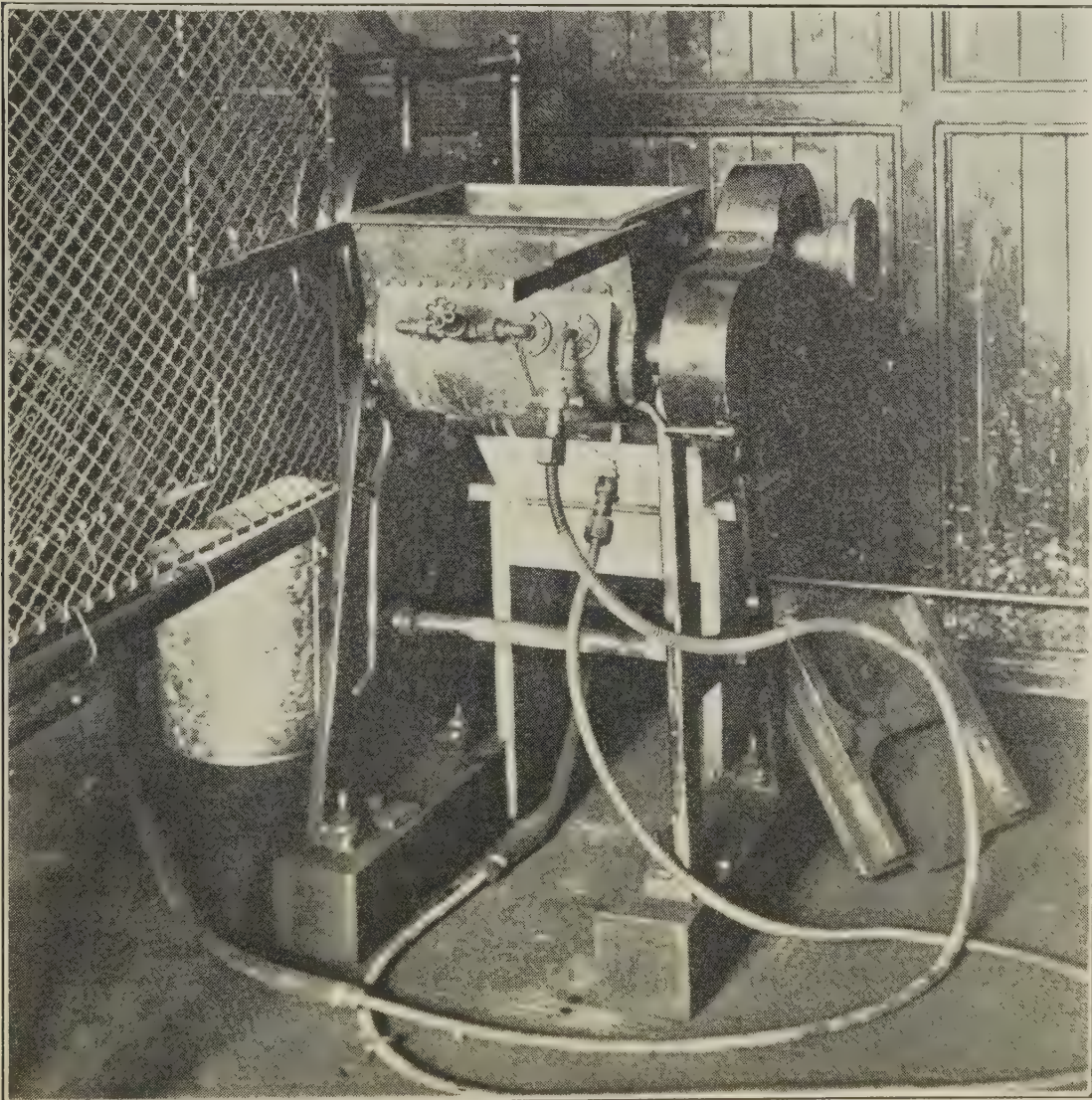


Figure 3.—Mixing Machine.

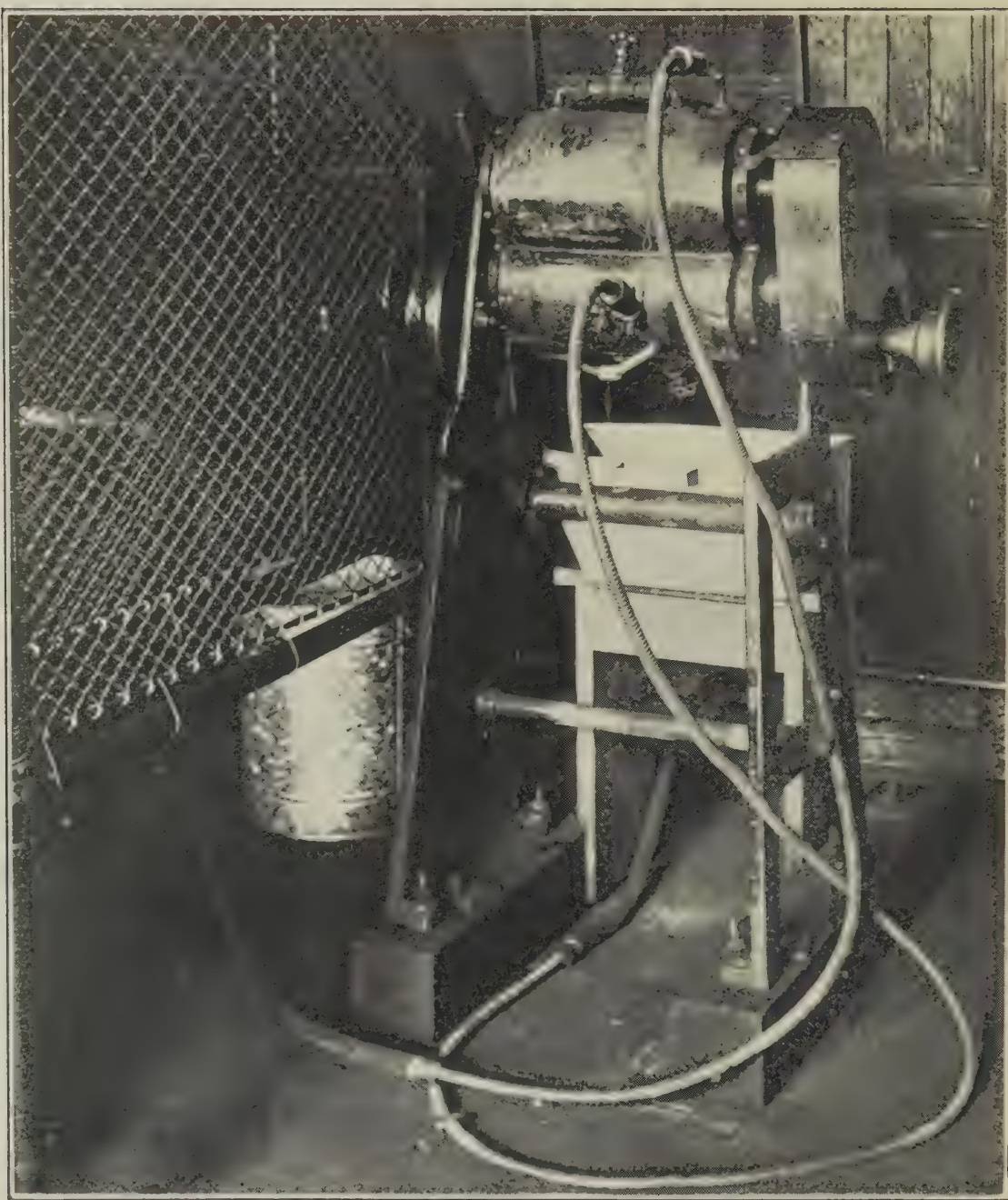


Figure 4.—Mixing Machine, Tilted.

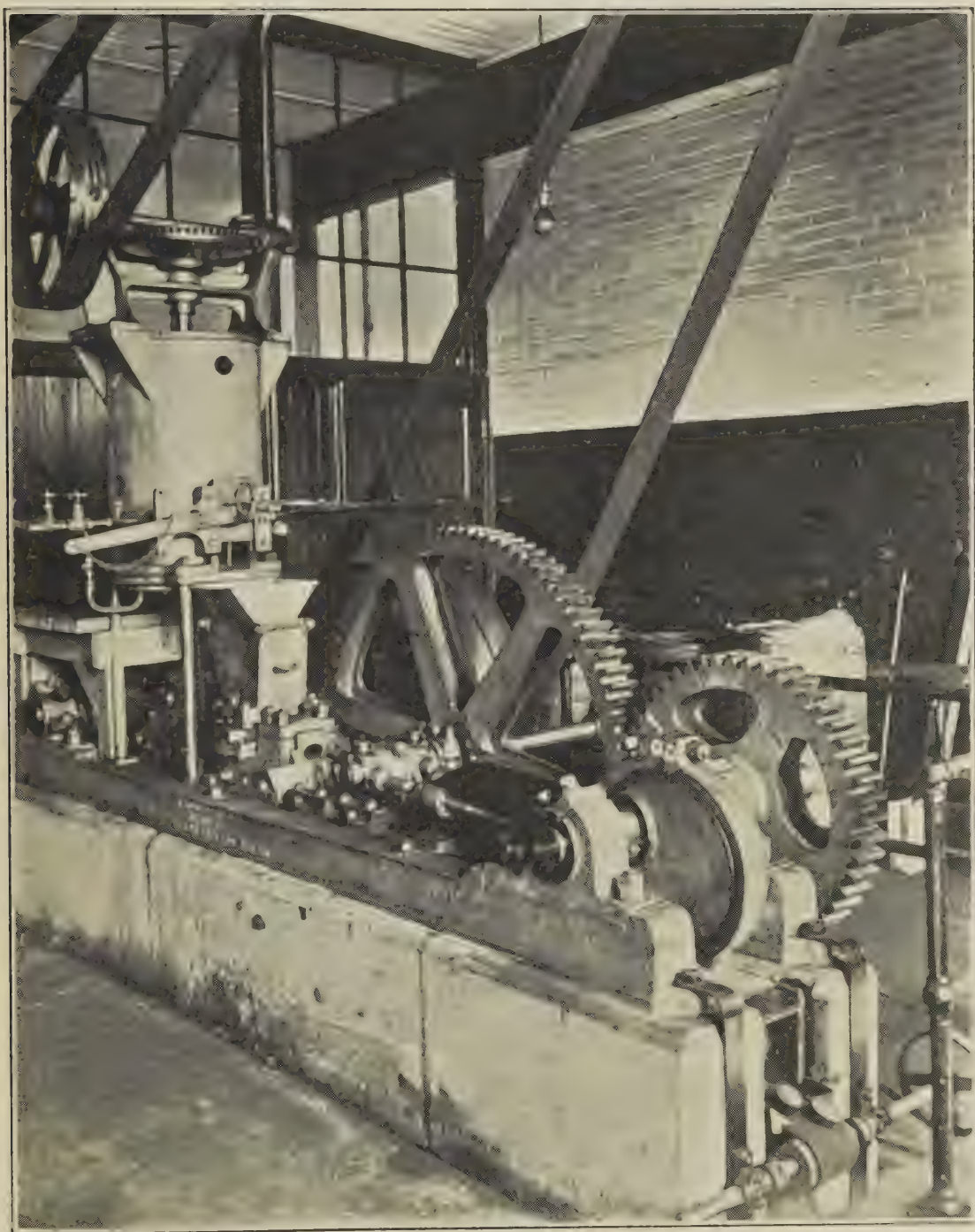


Figure 5.—Briquetting Press and Fluxer.

PLUNGER BRIQUETTE PRESS.
R. MIDDLETON & CO.
LEEDS, ENGLAND.

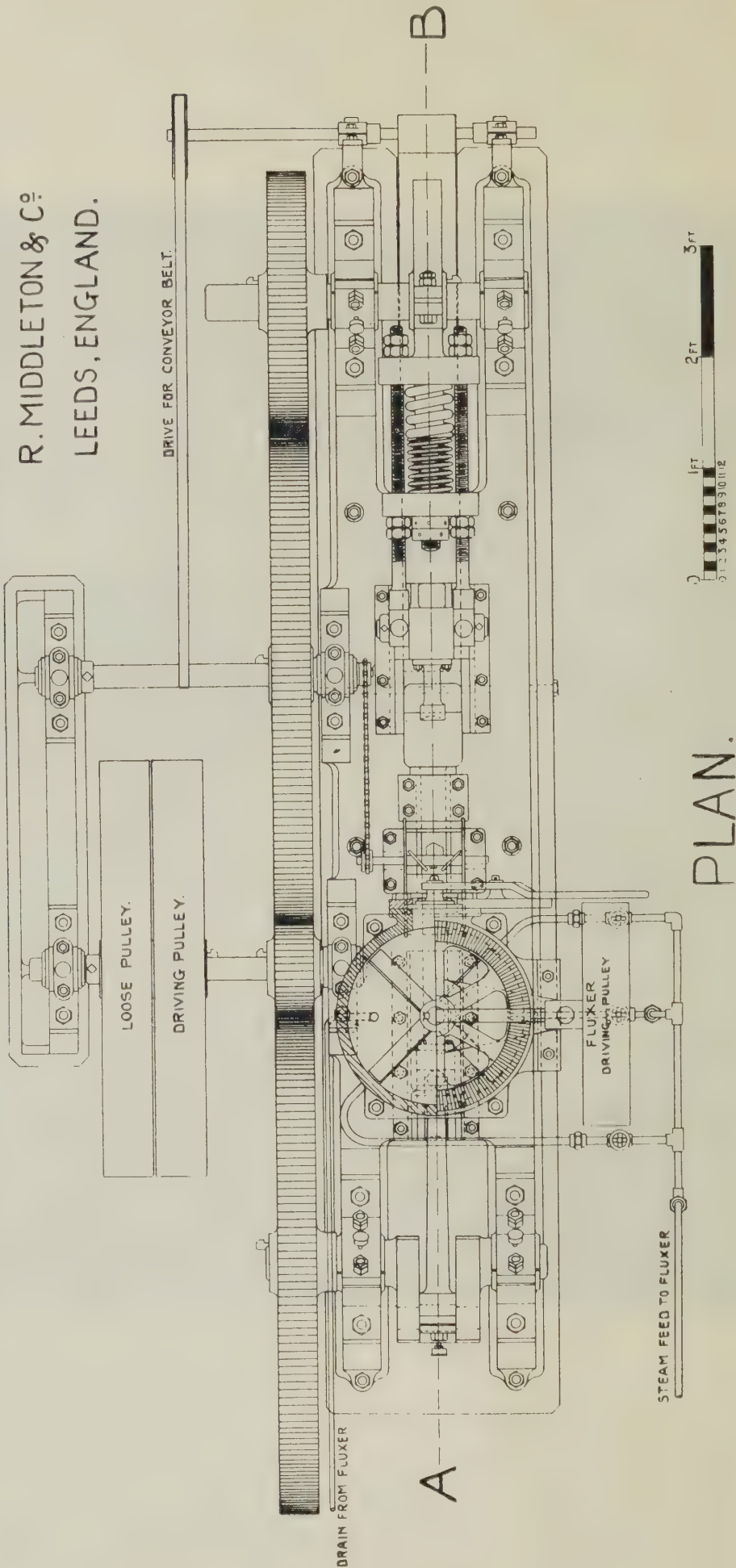


Figure 6.—Plan of Briquetting Machine

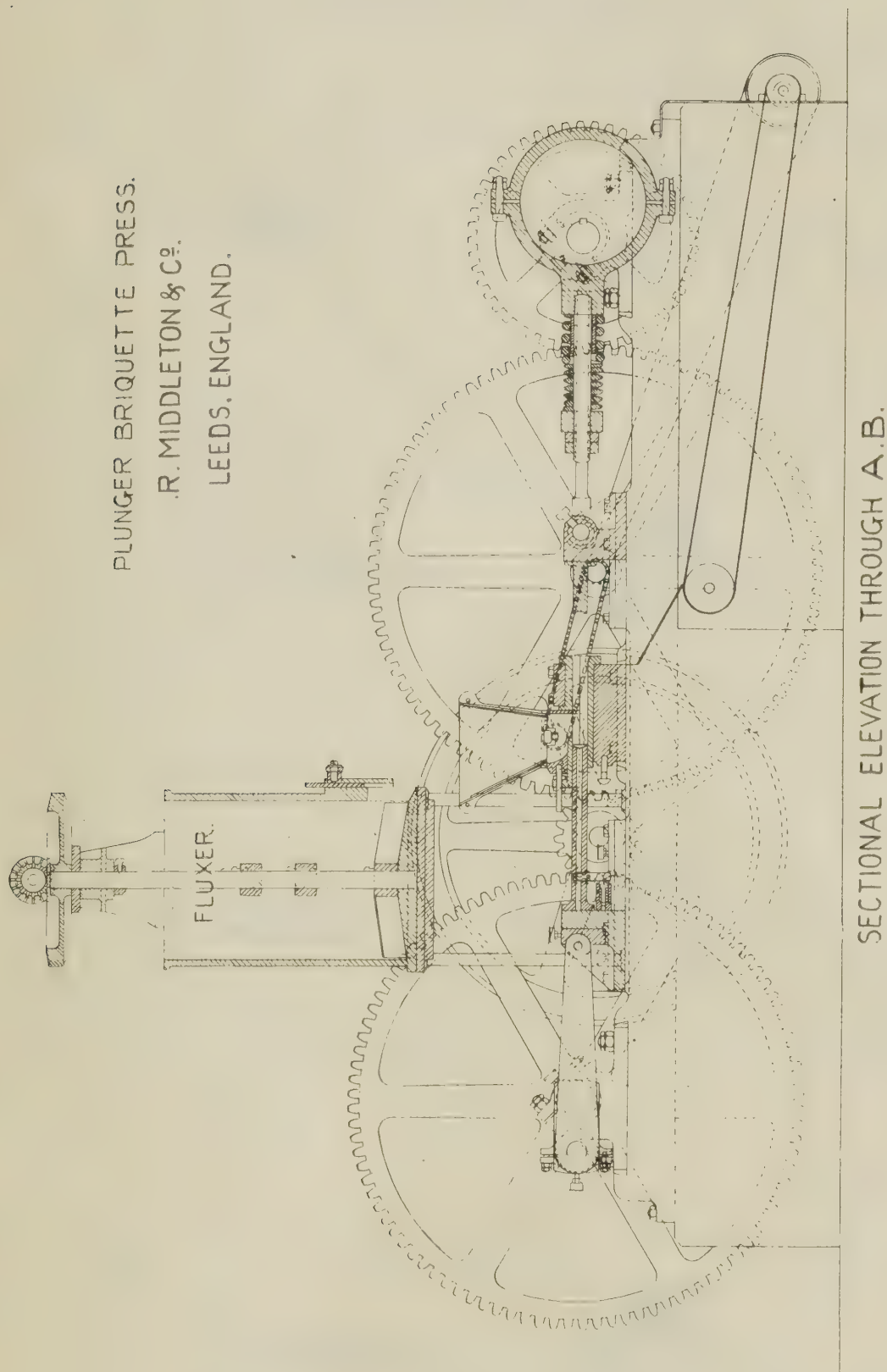


Figure 7.—Sectional Elevation of Briquetting Machine

BRIQUETTING OPERATIONS.

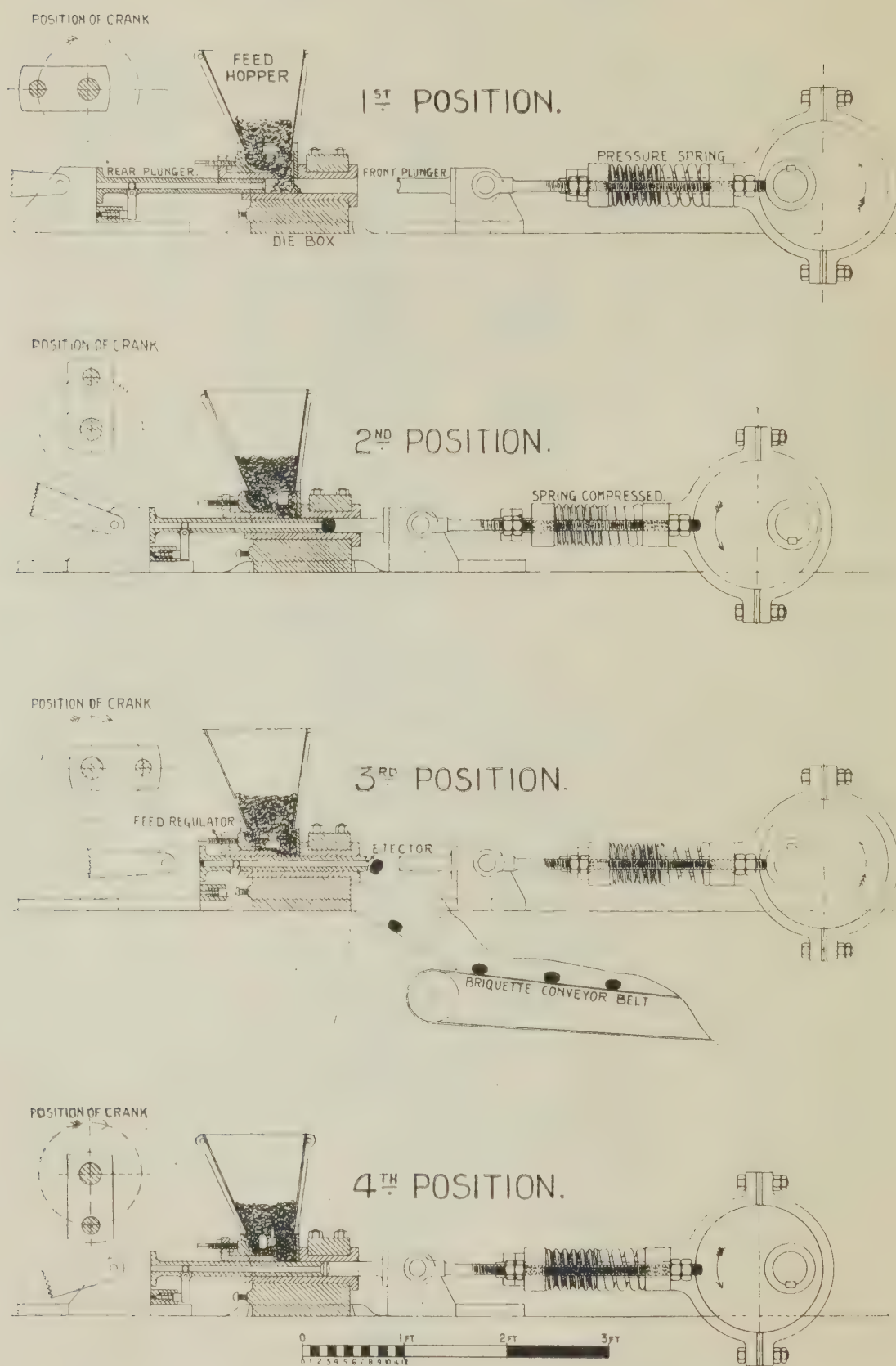


Figure 8.—Briquetting Machine, Diagram Showing Four Positions of Plungers.

The press makes about 25 briquettes per minutes. Their size can be controlled by a regulation of the feed, but they were usually made to weigh about four ounces. The pressure on the briquette can be regulated by adjusting the compression on the springs supporting the front plunger, by varying the size of the briquette, and by varying the clearance between the two plungers. The machine is rated to give a pressure of two tons per square inch, but so far the pressures employed have not exceeded $1\frac{1}{4}$ tons per square inch. A 10-h.p. motor is available to drive the equipment, but a slightly larger motor would be required for higher pressures.

The amount of binder in any batch of briquettes is recorded as parts by weight added to 100 parts by weight of coal. This is termed the "mixing ratio." The mixing ratio is slightly higher than the percentage of binder in the briquette. Thus if 8 parts of pitch were added to 100 parts of coal to make 108 parts of briquettes, the mixing ratio is 8, but the briquettes only contain 7.4% of binder. In addition to the above, records are also made of the adjustment of the press, the time taken for mixing, the maximum temperature attained in the mixing, the temperature of the mix as it is fed to the press, any addition of steam or water to the mix, also any special features, such as tendency to adhere to the plunger.

The briquettes are classified by inspection, by their specific gravity, by drop test, and by rattler test. Of these, the specific gravity and the rattler test appear to give the most satisfactory classification. Comparison of briquettes made from the same coal and same binder show that the quality of the briquette increases with the specific gravity, but the test can not be used to compare briquettes made with different types of coal. In the drop test, six briquettes are given a 10-foot drop onto a concrete floor, and the breakage determined, but this test has not been found to be reliable. The rattler test consists in placing 20 briquettes in the apparatus shown in Figure 9, which is then revolved 200 times at 32 r.p.m. The rattler is a standard machine adopted by the American Society for Testing Materials. The circumference is composed of cast iron plates, 6" wide, and $\frac{1}{4}$ " apart. The material rubbed off the briquettes as they roll around falls out between the plates, and the percentage loss of weight is determined. This appears to give a very satisfactory criterion of the quality of the briquette, except in the case of certain very soft briquettes which can be ruled out of count by inspection. Briquettes are also tested as to their behaviour in the fire. The tests are usually carried out on the briquettes about three days after they are made, but where a wet binder is used, the tests are not made until the briquette has had time to dry out.

The work of the year was limited to 3 months in the spring, until N. H. Atkinson left, and $2\frac{1}{2}$ months in the fall, after W. L. McDonald's appointment. The main objects sought during the year were: first, to establish the best procedure for making and testing briquettes; and, second, to compare the binding qualities of some binders. Altogether 159 batches of briquettes were made: 126 with bituminous coal, and 33 with carbonized lignite. Classified by

binders, these are: soft coal tar pitch, 97; hard coal tar pitch, 9; lignite pitch, 15; oil asphalt, 8; McMurray asphalt, 3; miscellaneous binders, 27.

Tests were made to study the best sizing of the coal, best temperature of mixing, minimum time required for mixing, best temperature for pressing, also the effect of addition of steam to the mix, and changes of pressure in the press. Soft coal tar pitch was used for most of these tests for the sake of uniformity, and because it is in some ways the easiest binder to use for such work. Comparative tests were also made on some binders. A number of mixed binders were made for study. Some of these appeared to have in themselves very desirable physical properties, but the results obtained with their use were very disappointing.

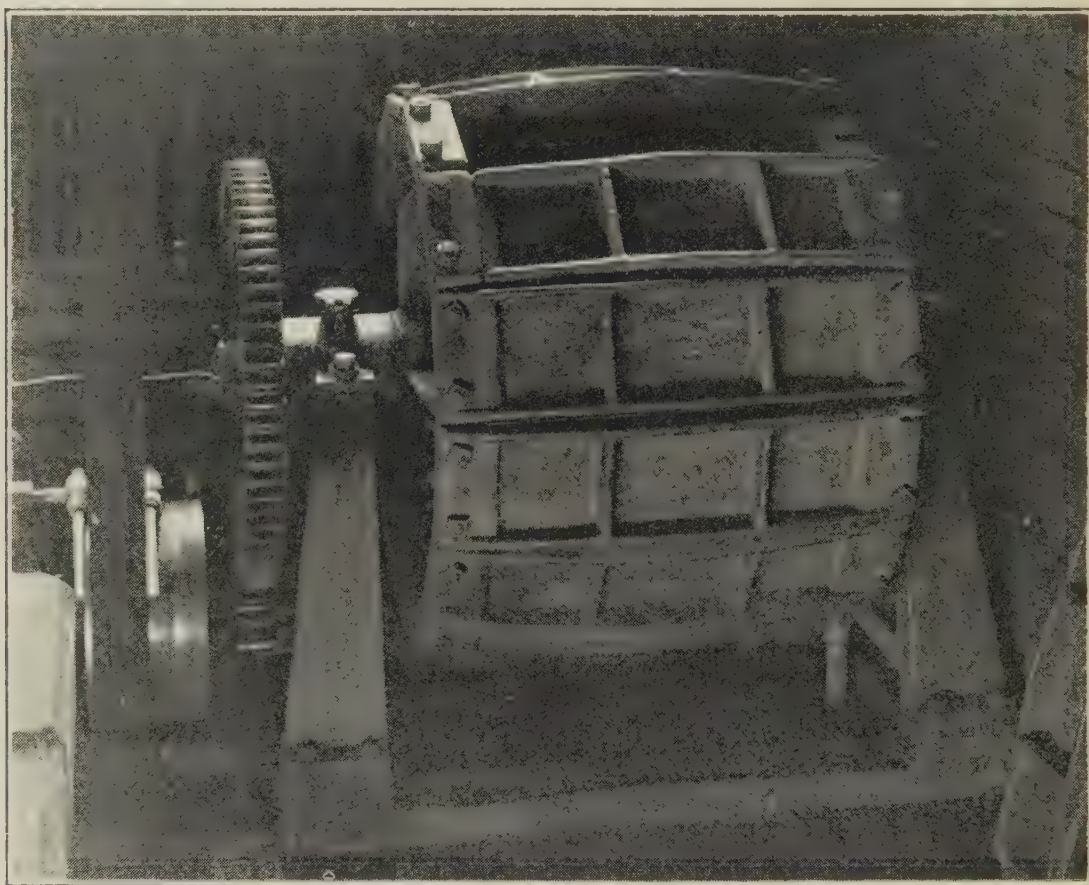


Figure 9.—Rattler for Testing Briquettes.

Briquetting tests are very difficult to carry out on account of the large number of variable factors affecting the result. Thus, a certain temperature at the press may be found to give the best briquettes after making many tests in which all the other factors are kept unchanged; but if the nature of the binder, or even its amount, is changed, it may be necessary to repeat all these tests over again to determine the best pressing temperature under the new conditions. Further, for each change of any factor, it appears necessary to redetermine the optimum conditions for every other factor, and thus an almost infinite number of tests are required. It is possible, with any particular coal, binder, mixer and press to experiment until good briquettes can be made, but this does not go far towards the goal of a scientific basis for the art of briquetting.

Furthermore, when good results can not be obtained with any binder, it is extremely difficult to decide whether this is because the binder is poor, or because the right combination of conditions does not happen to have been tried. Cases have been met where, after a very large number of failures, a slight change has resulted in the production of a really good briquette.

In view of the above, it was decided, when the work was resumed in the fall, to drop temporarily all briquette making, and to concentrate instead on a thorough physical examination of the available binders. This work is now in progress, and many interesting facts have been ascertained, but it is difficult as yet to say whether this new line of attack will give the desired results.

Tabulation of the results obtained would not be wise at present, but certain broad conclusions may be mentioned:—

(1) The quantity of binder required varies with the type of coal. Thus, a carbonized lignite requires from two to three times as much as a coking bituminous coal.

(2) The higher the temperature, the less time required for mixing; and prolonged mixing is harmful, especially if accompanied by abrasion of the particles.

(3) Although blowing steam through the mix has certain advantages, and is almost universally adopted in commercial work, a better briquette can generally be made under laboratory conditions without steam.

(4) Increase of temperature at the press results in increase of density of the briquette, but a limit is placed upon the temperature by the increasing tendency to stick to the plunger and by the friability of a hot briquette as it leaves the press. The tendency to stick to the plunger can be reduced by steam.

(5) Increase of pressure naturally increases the density of the product, but a large increase in pressure is required for a small increase of density.

(6) The effect of the size of particles in the crushed coal used on the quality of the briquette made is probably far less with a coking bituminous coal than it is with either anthracite or carbonized lignite. If the particles are too large, or the larger particles present in too great a preponderance, the briquette is coarse and friable. Finer crushing gives a smoother and more shiny briquette, but excessive dust increases the amount of binder required.

Table VII. shows the melting point of some of the binders, as determined both by the cube method and by the ring-and-ball method. The former, which is the one commonly used for pitches, always gives a higher result than the latter, which is commonly used for asphalts.

TABLE VII.—MELTING POINTS OF BINDERS

Method	Cube	Ring & Ball
BINDER:		
Soft coal tar pitch, sample A.....	66° C.	57° C.
Soft coal tar pitch, sample B.....	60°	50°
Hard coal tar pitch	81°	72°
Oil asphalt, sample A.....	66°	55°
Oil asphalt, sample B.....	....	62°
McMurray asphalt, sample A.....	....	67°
McMurray asphalt, sample B.....	....	71°

Table VIII. shows the effect of the pressure applied on the density of several briquettes made from the same batch of mix. Thus, 43% increase of the pressure only gave a 6% increase in density.

TABLE VIII.—EFFECT OF PRESSURE ON DENSITY OF BRIQUETTES

Pressure in tons per square in.	Specific Gravity
0.74	1.220
0.79	1.243
0.87	1.258
0.98	1.279
1.06	1.290

Table IX. gives the observed rattler test losses for briquettes made from a coking bituminous coal with differing amounts of four typical binders. The tests were made as comparable as possible, but, as already pointed out, it is difficult to insure the optimum conditions in every case. Each binder was tested out at two or more different mixing ratios.

TABLE IX.—COMPARISON OF BINDERS

Mixing Ratio	8	7	6	5	4
Binder	Rattler Loss, per cent.				
Soft coal tar pitch, sample B.....	14.6	18.7	21.6	31.9	100.0
Hard coal tar pitch .....	....	16.4	17.4	28.3	48.4
Oil asphalt, sample A.....	....	15.6	22.6	23.6	34.7
McMurray asphalt .....	....	12.1	16.6	....	....

For comparison with the above rattler test losses, it may be stated that egg-sized pieces of the original coal used for making these briquettes suffered a rattler loss of 44%. A freshly-mined lignitic coal and a sub-bituminous coal showed losses of 13% and 23% respectively, but the value for the former increased rapidly on storage. As a general rule, a briquette showing less than 20% rattler loss will be of good commercial value.

Samples tested in the rattler before and after two weeks exposure to frost and sun in the spring showed practically no change due to weathering. Three batches of briquettes which gave results of 15.0, 21.6 and 31.9% loss before weathering gave 15.2, 21.9 and 31.7% afterwards: in other words, no change.

WATER IN COAL

One of the most characteristic differences between the many types of coals occurring in this province is shown in their moisture content as mined, and their moisture retaining properties. For this reason the study of water in coal is particularly important here. The water occurring in coal is often divided into two parts: that lost in air-drying, and that retained after air-drying. If this division is to have real significance, the air-drying must be made a standard process. Thus, coal exposed in a room where the humidity averaged 20% would lose more than if the humidity averaged 80%; and the difference may be a large percentage of the total loss.

In the method adopted as standard, the coal is air-dried for two days in a current of air of 60% humidity. This is obtained by circulating the air by means of a fan through a pipe in which it is exposed to a large surface of calcium chloride solution of 1.30 specific gravity. This gives the air the desired humidity. From this pipe the air passes over the coal, down an extra regulating pipe, through the fan, and again up the regulating pipe and over the coal.

Figure 10 is a photograph of the apparatus with the door open, and shows eight trays of coal exposed for drying. It also shows the two bottles on the top from which the calcium chloride solution flows down, soaking a number of pieces of lamp wick in the regulating pipes, and finally running out into the two bottles underneath. From these bottles it is returned to the bottles on the top after it has been readjusted to 1.30 specific gravity. In an earlier form, solution was only run down the left-hand pipe, but it was found that at times, when the air in the laboratory was very dry, one regulating pipe was not quite sufficient to keep the air in the apparatus constantly at 60% humidity. It was easier to add an auxiliary regulating system for use at such times, than to construct an apparatus which, whilst easily opened and closed, was hermetically air-tight.

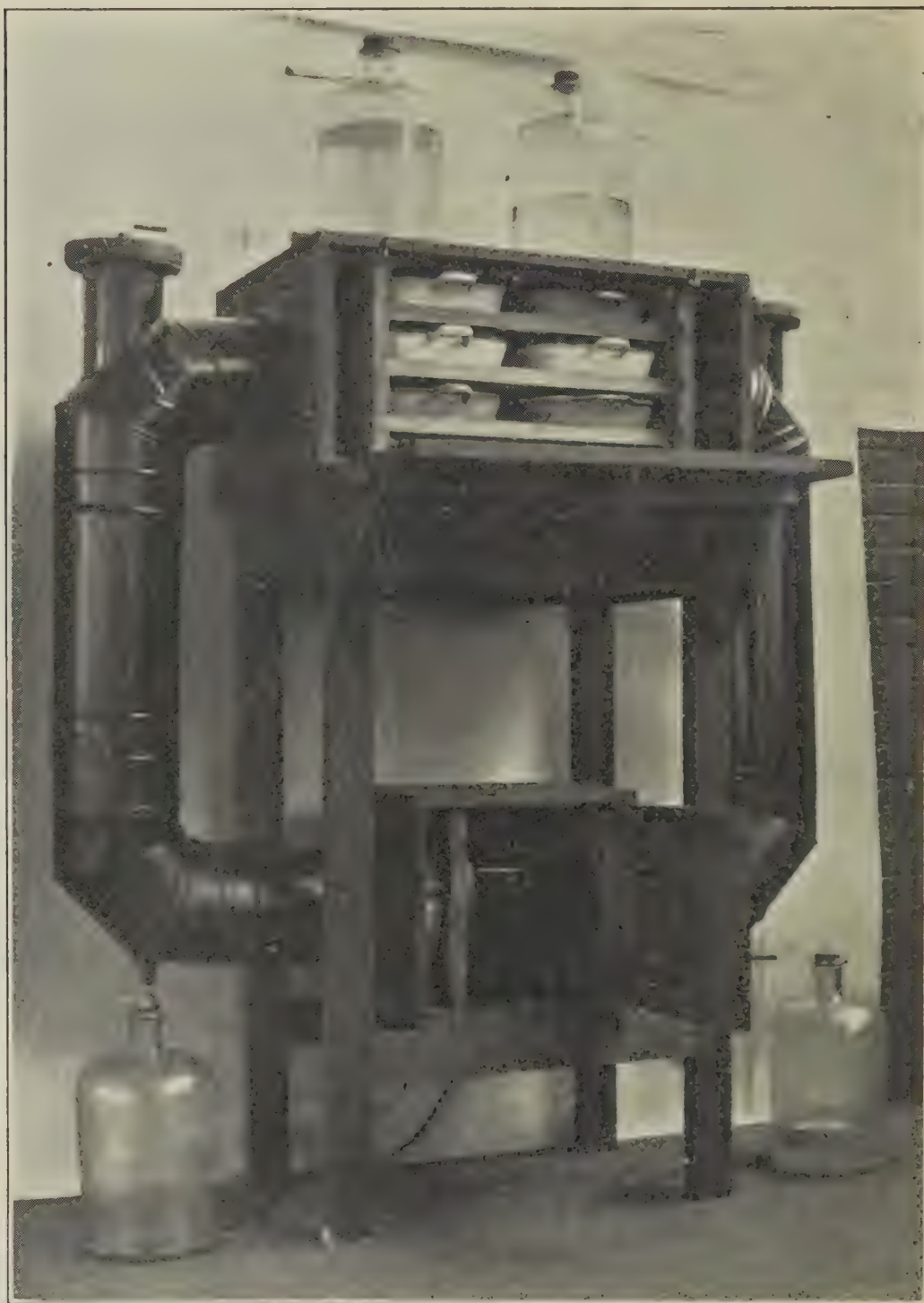


Figure 10.—Standard Air-drying Apparatus for Coal.
General View..

Figure 11 gives diagrammatic sections of the apparatus. Fuller details of the apparatus and method were given in a paper presented by E. Stansfield to the Western Annual Meeting of the Canadian Institute of Mining & Metallurgy.*

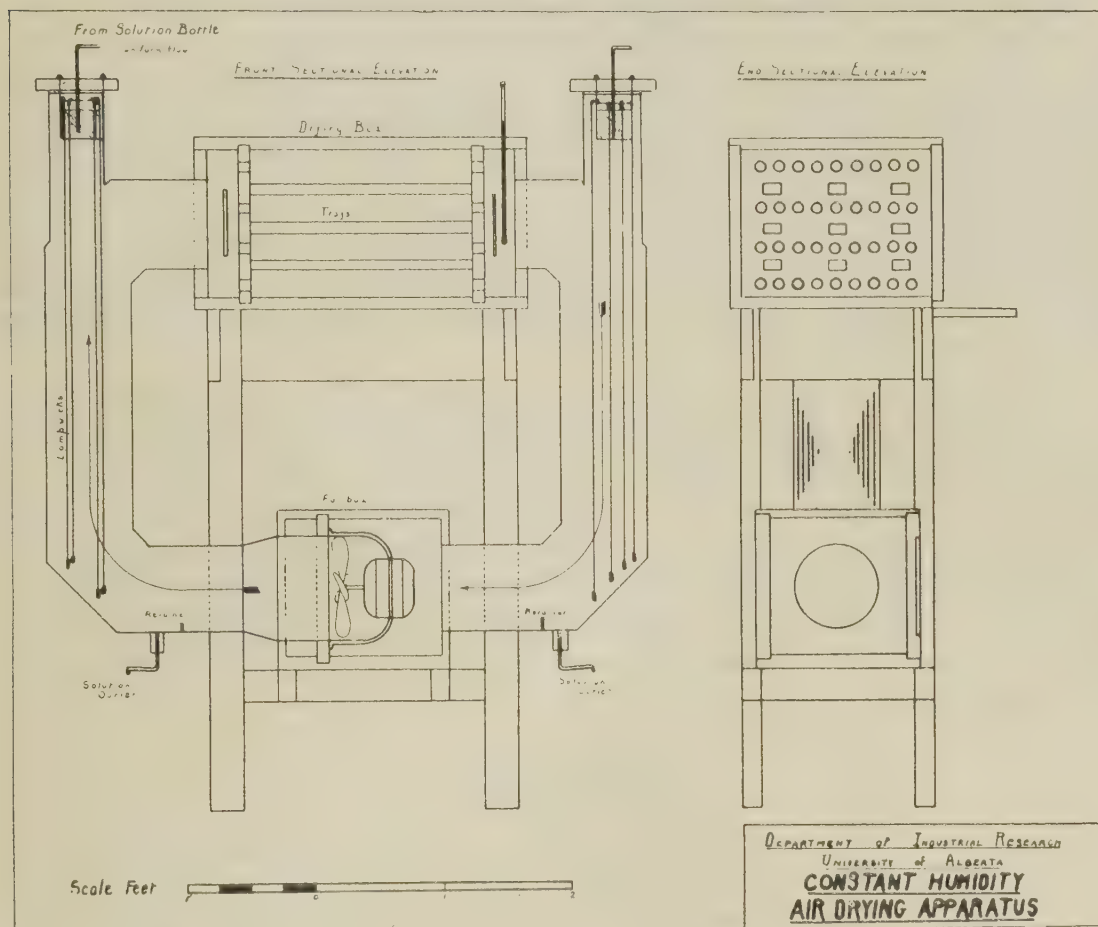


Figure 11.—Standard Air-drying Apparatus for Coal.
Sectional Elevations.

This method of air-drying has been adopted by the Department of Mines and the Department of Customs and Excise at Ottawa. Thus, in Bulletin 2814 of the Department of Customs and Excise, Lignite and Lignitic Coals are defined, for purposes of Customs, as having not less than 6% moisture content after being air-dried according to the method described above.

Work is in progress with regard to methods for determining the total moisture in coal, and to ascertain the effect of variations from the standard procedure.

Work is also in progress to find out the variations in the water content of coal deliveries from the same mine from week to week throughout a whole year. A sample has been taken each week since June 5th, 1923, from the slack coal delivered to the University Power House. The moisture content is determined in half the sample immediately, and in the other half after four weeks exposure to the air of an unheated shed. The second determination of moisture is made to show the variations in loss on exposure at

*"A Standardized Method for Air Drying Coals," Trans., Can. Inst. of Mining & Met., 1923, p. 615.

different times of the year. At the end of the year's test it is proposed to re-analyze all the samples in order to ascertain the extent of the changes undergone by coal samples stored in glass stoppered bottles in the laboratory.

Thirty-one of these delivery samples had been taken up to the end of the year. The average moisture found was 23.8%, the maximum 27.7%, and the minimum 17.4%. After exposure in the shed, the average moisture was 21.2%, the maximum 25.9%, and the minimum 16.3%. The change on exposure varied from a loss of 9.7% to a gain of 0.8% of water.

This series of tests, although not completed, has yet gone far enough to show the wide variations there may be in the moisture content of coal deliveries received by a consumer, even though they all come from the same mine.

Humidity records were taken in the above-mentioned shed during the last sixteen weeks of the year. These show extreme variations from about 25% to 100% humidity, with changes of up to 65% in less than 12 hours. The weekly averages, however, only varied from 61% to 89% during the period, with an average over the whole period of 75%. These records were taken with a Negretti & Zambra recording hygrometer. They are of considerable interest in connection with this work, but no great accuracy is claimed for this instrument.

NATURAL GAS

Some analyses were made of the natural gas supplied to the City of Edmonton. These showed a calorific value of 963 B.T.U. per cubic foot of dry gas at 60°F. and 30 inches of mercury. This is the gross calorific value. The net value is 91 B.T.U. lower. The determinations were made with a Simmance-Abady calorimeter with total heat attachment. In explanation of the above terms it should be stated that the calorific value of coals as usually reported is the gross calorific value. The net calorific value for coal would be from 2% to 8% lower, the difference increasing with the water content of the coal.

COMBUSTION OF COAL FOR THE GENERATION OF POWER

A report has been prepared on the above subject by Prof. C. A. Robb. A summary of this report is given below, and a multi-graphed copy of the text of the report itself will be forwarded to anyone interested on the receipt of 50 cents. Blue prints of the drawings referred to may be consulted in the office of the Industrial Research Department at the University, or might be seen at the offices of the engineers of the plants concerned.

REPORT OF COMMITTEE ON COMBUSTION OF COAL FOR THE GENERATION OF POWER

BY CHARLES A. ROBB,
Professor of Mechanical Engineering,
University of Alberta.

INTRODUCTION

With a view to the possibility of it being advisable in the future to initiate an extensive programme to determine the best designs for boiler furnaces to burn the different types of Alberta coals, the Scientific & Industrial Research Council of Alberta, on April 19th, 1923, advised that the writer had been constituted a committee to consult with the principal combustion engineers of the Province, and collect, tabulate and digest all available information on the subject of the "Combustion of Coal for the Generation of Power."

Correspondence was opened on June 13th, 1923, with various engineers, requesting that they co-operate by forwarding to the writer data covering the results of their experimental work in regard to the burning of Alberta coals, and stating what steps they had taken to improve the efficiency of their furnaces.

The main object of this investigation was to accumulate such a collection of data covering the use of Alberta coals in power plants as would assist investigators in establishing new lines of endeavour, and also prevent duplication in the matter of results already accomplished. It was felt that an investigation covering the question of establishing more efficient furnaces to serve steam boilers burning the sub-bituminous or lignite coals would prove very profitable.

The request for information was sent to 18 engineers, and in all 14 replies have been received. In some cases no information was available. The contributions, hereafter called memoranda, have been arranged alphabetically, and the contents abridged as far as seemed advisable. The current technical press has been explored for material, and some extracts bearing on the problem have been included.

In order that a comparative analysis of the material received could be made, the following details were asked for in each case: plans or sketches of special furnaces; reports showing the results obtained by the different modifications of the furnace; views as to the lines on which investigation had proved most profitable; general information as to make, type, etc., of boilers and furnaces.

It should be noted that the problem is being approached primarily with a view to assisting towards a maximum efficiency in burning, for power purposes, the higher moisture coals, preferably the cheaper sizes.

An example of the results from experimental work already done is found in the utilization of lignite slack, formerly wasted, and of which the reclamation value in the current year is approximately \$500,000. The slack now costs the consumer about half the price of nut coal, which represents gain to the operator, and a 50% saving to the consumer.

For the purpose of a study of the problem of the boiler furnace, the following elements require consideration:—Fuel; heating surface for rating; grate area; type of furnace, externally or internally fired, hand-fired or stoker-fired, chain grate or underfeed; volume of combustion space; percentage of rating for best results; flexibility; draft; ash; clinker.

The full report includes: (a) List of contributors; (b) Digest of special remarks; (c) Extracts from the technical press; (d) Tendencies in past investigations; (e) Profitable lines for future investigation; (f) Conclusions; (g) Acknowledgments; (h) Index to digest of special remarks; (i) Bibliography of technical references; (j) Memoranda. Item (j) is not included in the multi-graphed copies available for distribution, but may be consulted in the office of the Industrial Research Department at the University.

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Jos. S. Eby, Superintendent, Municipal Power Plant, Camrose.

Jas. F. McCall, R.P.E., Superintendent, Calgary Power Department.

E. H. Oliver, Superintendent of Public Utilities, Macleod; late Superintendent of Government Power Plants, Alberta.

Geo. R. Pratt, A.M.E.I.C., R.P.E. (Man.), Fuel Engineer, Province of Alberta.

Chas. A. Robb, M.E.I.C., R.P.E., Professor of Mechanical Engineering and Resident Engineer, University of Alberta.

J. T. Watson, R.P.E., Chief Engineer, Lethbridge Power Plant.

CONCLUSIONS

Mechanical Stokers.—Progress has been made in burning the lignite coals in chain grate and underfeed stokers. Equipment already installed of this class will serve for further experimental work, and it is natural to expect such work to continue with the prospect of early economic return as an incentive. It is understood that installations have been made of the following stoker equipment, although no data regarding them has been included by any of the contributors: Allan, Cox, Turbine.

Other stoker manufacturers whose equipment permits of liberal combustion space might be encouraged to make experimental installations.

Hand-Fired Boilers.—A large proportion of the present hand-fired installations have been designed for the use of bituminous coal and do not have the large combustion space which seems desirable.

It would seem necessary, in case any comprehensive programme of research were contemplated, to provide a boiler of the type in common use, i.e., 100 H.P., H.R.T., and equip this boiler with a furnace designed to permit of the space between the grate and the shell being varied, and making provision for the installation of various arches, baffles and bridges.

ACKNOWLEDGMENTS

The writer desires to express his thanks to the engineers who have so kindly contributed the results of their experimental work and experience to this report, and to Mr. R. R. Couper, who has assisted in compiling the material.

GEOLOGICAL INVESTIGATIONS DURING 1923

BY JOHN A. ALLAN

INTRODUCTION

In the first four months of the year considerable time was spent in completing reports on "Saunders Creek and Nordegg Coal Areas" and "An Occurrence of Iron on Lake Athabaska," and in getting these reports and the accompanying maps published. These two reports constitute the Fourth Annual Report on the Mineral Resources of Alberta.

In order to avoid duplication of field work by the Federal and Provincial Geological Survey parties an endeavour was made to arrange co-operation with the Geological Survey of Canada. In May a visit was made to Ottawa to discuss details, which were arranged satisfactorily. The author has pleasure in recording the willingness to co-operate on the part of the geological officials, and particularly Dr. W. H. Collins, Director of the Geological Survey. The working arrangement agreed upon is that, in so far as coal areas are concerned, the provincial geological work will be carried out as far as possible on the upper Cretaceous coal-bearing formations, and on those of Kootenay age lying east of the front of the Rocky mountains. The Federal Geological Survey will concentrate field investigations on coal areas of Kootenay age within the mountains. By thus avoiding duplication of field surveys, data on the coal areas in Alberta will be obtained more rapidly.

One field party spent four and a half months in the field, and continued the survey of the coal-bearing and associated formations in the foothills between the North Saskatchewan river and the McLeod river. The details of this investigation and the results obtained comprise Report No. 9. The summary of this work is given below.

A short visit was made to the southwest corner of the province to investigate an occurrence of iron-bearing shales near the east end of Waterton lake. These shales are not considered of sufficient importance to warrant recording geological data concerning them.

Some time was spent on examining and correlating the rock core of Salt Well No. 2, drilled at Waterways. Details of these operations are given below. When at Waterways, a trip was made up Clearwater river about 65 miles in order to obtain data on the bituminous sands and the underlying Devonian formation along this section. A few notes on this section are included below.

A geological map of Alberta is being prepared. This map will contain available geological data to date, and will also show the general character of the surface with contour lines drawn at 500 foot intervals. The scale of this map will be about one inch to 25

miles. The base map has been completed, and geological data are being compiled. It is hoped that this map will be completed and published before the end of the year.

GEOLOGICAL SURVEY OF THE FOOTHILLS BELT BETWEEN NORTH SASKATCHEWAN AND MCLEOD RIVERS

The geological survey of the foothills belt, commenced in 1922, was continued in 1923. The area examined lies between the Nordegg coal basin and the Bighorn mountains, and follows the disturbed belt in the foothills from North Saskatchewan river, north to McLeod river. This area, representing about 1,625 square miles, forms a belt with a northwesterly trend, approximately 65 miles long and 25 miles wide. The results of this investigation form Report No. 9, prepared by R. L. Rutherford and the writer. This report is entitled "Geology along the Blackstone, Brazeau and Pembina Rivers, in the Foothills Belt, Alberta." The data upon which this report is based were obtained in the field between May 20th and September 15th. The field work was under the charge of R. L. Rutherford, with W. G. Jewitt as field assistant. The writer also spent about six weeks with the party. The report is accompanied by a geological map in six colors, on the scale of one inch to two miles, and by five structure sections along the major rivers.

The general physiographical features are shown by sketched contour lines with 100-foot intervals, but these must be regarded as only approximately correct. Rock outcrops in the interstream areas are scarce, so that most of the season was spent traversing the major streams and compiling the data from outcrops along the sides of the valleys. On account of the unusually wet season, the trails in many places were almost impassable, but the trail traverse for the season represents over 600 miles.

In this survey, the lithological and structural relations of the various formations were established in so far as it was possible to do so without a topographical map. Special attention was given to the coal-bearing formations with respect to their age, thickness, lateral persistence and continuity.

In this area there are two important coal-bearing formations: the Kootenay formation of lower Cretaceous age, and the Saunders formation of the upper Cretaceous age in the Montana group which corresponds in part to the Belly River series in other parts of Alberta.

The structure in the foothills belt varies from east to west. On the eastern side the folds are open; but the folds are closer, more numerous, and more complex to the west in the inner foothills. This increased deformation culminates in the over-thrusting of the Paleozoic strata of the Bighorn and Nikanassin ranges on the top of the Cretaceous. The formations are broken by several major faults and many minor faults.

The rocks of the Kootenay group in this part of the foothills have been divided into two members, namely, the *coal-bearing member* below, and the *McLeod member* above. All the strata in these two members are of continental origin, and the thickness is believed to be less than 5,000 feet. The horizon represented by the

McLeod member has been designated as of Dakota age in southern Alberta, but there is no field or lithological evidence for separating this upper member as a formation from the lower, coal-bearing, formation in this area. The Kootenay strata occur in rather limited, disconnected belts in the more complex structure, and form the Nordegg, Bighorn, Medicine Lake, Cadomin-Luscar, and Mountain Park coal basins. Mining operations are carried on in the first and in the last two mentioned basins, while preparations are being made to open up the coal seams at Medicine lake.

The upper Cretaceous, coal-bearing formation occurs in the Montana group of strata, and has been called the *Saunders formation* because the coal seams are mined at several places in the vicinity of Saunders creek. This formation corresponds in age to the Belly River series in central and southern Alberta, but in this part of the foothills the beds are all of fresh water origin.

One of the main objects of this survey was to correlate the coal seams at Saunders creek with those mined along the Coal Branch in the vicinity of Coalspur. This object has been accomplished. In the Saunders Creek basin the coal seams are limited to a series of beds about 170 feet in thickness. To the northwest, between Blackstone river and Coalspur, there are five distinct coal horizons, numbered from the lowest, separated respectively by 4,500, 1,000, 2,000, and 5,000 feet of sediments, also of Montana age, but without coal seams of importance. The coal seams between Lovett and Coalspur are correlated with the third coal horizon.

The top of the Saunders formation has not yet been determined, but at least 15,000 feet of sediments have been recognized in this formation. The upper beds in the formation will probably be correlated with the Edmonton or higher formations occurring east of the foothills belt.

SALT WELL No. 2 AT WATERWAYS

In order to determine the possible occurrence of rock salt in commercial quantities in northern Alberta, two wells have been drilled by the Provincial Government along the Clearwater river in the vicinity of McMurray. Well No. 1 was drilled in the town-site of McMurray, 300 miles north of Edmonton. This well was completed in November, 1921, at a depth of 685½ feet. Several beds of rock salt were encountered, the largest of these measuring 14 feet of pure transparent rock salt. An analysis of this salt shows over 98% sodium chloride. The record of this well, and the details of the results, were published by the writer in the Second Annual Report on the Mineral Resources of Alberta, 1920, page 102.

As the present terminus of the Alberta and Great Waterways Railway is at Waterways on Clearwater river, six miles east of McMurray, it was decided to drill a second well close to the railway to determine if workable beds of salt extend eastwards to the "end of steel." The writer located the site of Salt Well No. 2 about one hundred yards from the railway at the junction of Deep creek and Clearwater river, in section 32, township 88, range 4, west of the 4th meridian. Well No. 2 was drilled under the direction of the Provincial Mines Branch. Drilling operations began in the month

of October, 1922, and this well was completed in September, 1923. Mr. George Henry was in charge of field operations, and Mr. S. Boyd was driller. The well was drilled with the same Davis calyx rotary drill used on Well No. 1, and the rock core was preserved.

The well was started 8 inches in diameter, and carried through the unconsolidated material 40 feet thick. The bottom of the hole, at 789 feet, is 4½ inches in diameter. The hole is cased to a depth of 668 feet. The details are as follows:

Diameter of Hole	Size of Casing	Depth from Surface
8 -inch	.....	40 feet
6 ½ -inch	6 ¼ -inch I.D.	445 feet
5 ½ -inch	5 -inch I.D.	668 feet
4 ½ -inch	No casing	789 feet

A very complete rock core was obtained, except where the beds were soft and were washed away. All the core obtained was boxed, labelled and examined in detail. For future reference the rock core, from 400 feet to the bottom of the well, and about 150 feet of selected core above that depth, has been shipped to Edmonton, and is now preserved in the geological museum at the University of Alberta. The rock cores from the two salt wells drilled in the vicinity of Waterways and McMurray contain an accurate record of the formations in this part of Alberta, and are available for further study by anyone interested in the character of the rocks.

The elevation of the surface of Well No. 2 is 810 feet above sea-level. A marked change in the formation, from limestone and shale to gypsum, anhydrite, and dolomite, occurs at a depth of 415 feet below the surface. The corresponding change in the McMurray well occurs at 500 feet below the surface. Since the surface elevation in Well No. 1 is about 800 feet above sea-level, the difference in elevation of the horizon represented by the change of formation is about 95 feet. This indicates a rise in the formation towards the east between the two wells. The massive limestone between 141 and 211 feet in Well No. 2 corresponds to the similar formation encountered in Well No. 1 between 223 and 290 feet. Other horizons in the two wells can be easily correlated.

There are no beds of pure rock salt in the Waterways well, but there are many thin and unworkable lenses of salt, and numerous irregular patches of salt interspersed with gypsum and dolomite.

The first indications of salt were encountered at about 490 feet from the surface. The core contains numerous cavities in the gypsum; in some of these salt crystals still remain. From this point to the bottom of the well there are several horizons where gypsum, anhydrite, and dolomite are interspersed with salt crystals and lenses of salt, but no beds of pure sodium chloride were encountered.

A detailed section of the rock core is given below.

LOG OF SALT WELL NO. 2, WATERWAYS, ALBERTA

Location:—Section 32, township 88, range 4, west of 4th meridian.

Elevation above sea level:—810 feet.

STRATA.	Thickness,		Depth from	
	ft.	ins.	Surface,	ft. ins.
Unconsolidated sand and gravel	40	0	40	0
Limestone, massive, grey	3	2	43	2
Shaly limestone	4	2	47	4
Shale, dark grey	10	0	57	4
Limestone, massive	2	0	59	4
Shale	14	7	73	11
Shale and thin limestone interbedded.....	2	1	76	0
Shale, massive, calcareous	7	0	83	0
Limestone, shaly	3	2	86	2
Shale, calcareous, interbedded hard layers.....	10	4	96	6
Shale, massive, calcareous	44	7	141	1
Limestone, massive, mottled, grey, fossiliferous..	10	0	151	1
Limestone, massive, grey, fossiliferous	60	1	211	2
Limestone, shaly	1	3	212	5
Limestone, massive, grey, fossiliferous	19	7	232	0
Shale, soft calcareous	2	0	234	0
Shale, hard, calcareous	3	6	237	6
Shale, soft, blue, calcareous	1	11	239	5
Shale and limestone, soft, interbedded	4	0	243	5
Shale, fissile, calcareous	4	1	247	6
Shale, soft, blue	2	1	249	7
Shale, hard, fissile, dark grey	6	0	255	7
Limestone, hard, fissile, mottled	1	5	257	0
Shale, soft, bluish, calcareous	7	0	264	0
Limestone, grey, fossiliferous	1	7	265	7
Shale, fissile	4	4	269	11
Limestone, fossiliferous	1	10	271	9
Shale, soft, bluish	7	3	279	0
Shale, grey, calcareous, fossiliferous	9	6	288	6
Limestone, massive, grey, fossiliferous	37	4	325	10
Shale, bluish grey, calcareous	3	8	329	6
Limestone, mottled, fossiliferous	2	6	332	0
Shale, grey, calcareous, fossiliferous	5	7	337	7
Shale and limestone, interbedded	4	5	342	0
Shale soft (easily caved)	17	5	359	5
Shale, bluish, and limestone, grey, interbedded..	1	2	360	7
Shale, soft, bluish, calcareous, very fossiliferous	7	0	367	7
Shale and limestone interbedded	0	8	368	3
Limestone, mottled, grey	2	0	370	3
Shale, soft, bluish grey	3	4	373	7
Limestone, argillaceous	1	10	375	5
Shale, soft, calcareous	18	7	394	0
Shale, hard, calcareous, with pyrite.....	7	0	401	0
Limestone, fossiliferous	3	0	404	0
Shale, hard, fossiliferous	6	0	410	0
Limestone, massive, grey, fossiliferous	4	6	414	6
Limestone, massive, block	0	6	415	0
Anhydrite, and gypsum, banded	5	0	420	0
Anhydrite, massive	7	0	427	0
Anhydrite with thin bands of gysum and shale..	14	0	441	0
Anhydrite, massive, veined with gypsum	7	0	448	0
Shale, massive	2	0	450	0
Gypsum and anhydrite, pink, thin bedded	2	0	452	0
Dolomite, pinkish, banded	1	0	453	0
Shale with gypsum veins	2	6	455	6
Shale with anhydrite	2	6	458	0
Shale, soft, grey	8	0	466	0

STRATA.	Thickness, ft. ins.		Depth from Surface, ft. ins.	
Anhydrite, massive, grey	6	0	472	0
Dolomite, chocolate colored, with gypsum	2	0	474	0
Anhydrite, with pink bands of gypsum.....	15	0	489	0
Gypsum, mottled, folded, with salt cavities.....	13	0	502	0
Gypsum, mottled, and whitish anhydrite	13	0	515	0
Gypsum, mottled	48	0	563	0
Gypsum, white and grey banded.....	17	0	580	0
Anhydrite, hard, bluish, with gypsum veins.....	7	0	587	0
Dolomite, chocolate, banded with gypsum	7	2	594	2
Dolomite, banded with gypsum	7	10	602	0
Dolomite, massive, brownish	26	6	628	6
Dolomite, massive, with irregular veins of selenite	8	0	636	6
Dolomite, massive, with salt pits	7	0	643	6
Dolomite, massive, with irregular patches of selenite	7	0	650	6
Dolomite, yellowish, with salt cavities.....	8	6	659	0
Dolomite, yellowish, with salt and selenite crystals	7	0	666	0
<i>(Salt water flow, 24 gallons per minute)</i>				
Dolomite, brownish, with salt cavities.....	8	0	674	0
Dolomite, brownish, with gypsum lenses and salt crystals	6	0	680	0
Dolomite, brownish, pitted, with gypsum veins..	6	0	686	0
Dolomite, with selenite lenses and 2" band of fibrous gypsum	6	0	692	0
Dolomite, brownish, with salt cavities and gypsum	10	0	702	0
Dolomite, thin-bedded, with gypsum layers and lenses	2	0	704	0
Dolomite, thin-bedded, with gypsum lenses and salt crystals	10	0	714	0
Dolomite, yellowish, with pronounced dip	8	0	722	0
Anhydrite, salt and gypsum lenses.....	4	0	726	0
Anhydrite, white, with salt lenses.....	3	0	729	0
Dolomite, dark grey, massive	4	0	733	0
Dolomite, yellowish, brittle	3	0	736	0
Dolomite, yellowish, with gypsum lenses 1" in diameter	5	0	741	0
Anhydrite and gypsum, thin-bedded	8	0	749	0
Anhydrite and gypsum, massive	11	0	760	0
Dolomite, massive, with selenite lenses.....	6	0	766	0
Gypsum, white, fibrous, thin-bedded, with anhydrite and shale	14	0	780	0
Gypsum, with many angular grains of quartz....	2	0	782	0
Quartz, angular grains, with gypsum matrix....	3	0	785	0
<i>Contact of pre-Cambrian granite</i>			785	0
Granite, grey, coarse	4	0	789	0
<i>Bottom of Well</i>			789	0

The strongest indications of salt occur at 666 feet, where a strong flow of brine was encountered. The flow was measured, and found to be represented by 24 gallons per minute. The temperature of the brine at the casing-head is about 43°F. The gravity of the water taken with an hydrometer at the well site showed 15.5% salinity. The following analyses of the brine were made by J. A. Kelso, Director of the Industrial Laboratories, University of Alberta:

	No. 1	No. 2
Specific Gravity	1.1130	1.1125
Insoluble Matter	0.12%	nil

Composition of Soluble Matter:

Sodium Chloride	97.20%	97.12%
Calcium Sulphate	2.23%	2.09%
Magnesium Sulphate	0.41%	0.48%

Note:—The insoluble matter in No. 1 consisted of iron sulphide. This sample contained a large amount of sulphuretted hydrogen.

Samples of the brine were evaporated, and a pure white salt was obtained. Analyses of this salt made by J. A. Kelso are as follows:—

Composition of Soluble Matter:	No. 1	No. 2
Sodium Chloride	96.80%	97.21%
Calcium Sulphate	2.01%	2.12%
Magnesium Sulphate	0.81%	0.51%

By calculating the flow and the salinity of the brine, the salt content from this brine is represented by about 225 bushels, or 6.2 tons, or 62 barrels, per 24 hours. This calculation indicates that there is a considerable quantity of rock salt interspersed with the other rocks, but there are no workable beds indicated in the rock core. If fuel could be obtained cheaply, this brine might have commercial possibilities; but the cost of producing salt by evaporation of the brine is too great under present conditions.

Provided the salinity of the brine and the flow remain constant, this well is capable of producing 2,263 tons, or 22,630 barrels of salt per year, or approximately 15% of the present consumption of salt in Alberta, calculated from the per capita consumption of salt in the whole of Canada.

At 780 feet there is another change in the rock formation from gypsum to a fragmental rock consisting of angularly rounded grains of clear quartz, some mica, and less feldspar, held together with crystals of gypsum. This rock continues for five feet, and at 785 feet the surface of the pre-Cambrian granite was encountered. This completed the chances of finding rock salt, but the well was drilled four feet into the granite, as the writer at that time was with the survey party in the foothills, away from telegraphic communication. It was not until the drill had reached 789 feet that the writer had an opportunity to examine the rock core and to stop drilling operations.

According to the Dominion Bureau of Statistics, the salt consumption in Canada in 1922 was as follows:

Domestic salt, all grades	177,193	tons
Imported salt for use in fisheries	82,185	"
Imported salt in bulk, barrels and bags.....	113,685	"
Total.....	373,063	"
Salt exported	740	"
Annual consumption in Canada	372,323	"
Population of Canada (1921)	8,788,483	
Consumption of salt per capita: gross.....	84	lbs.
After deduction for salt used in fisheries.....	66	lbs.
After deduction for brine used in chemical works	53	lbs.

The population of Alberta in 1921 was 588,454. Assuming that the consumption of salt in this province corresponds to that of the whole of Canada, that is, 53 lbs. per capita, the annual salt requirements in Alberta are about 15,594 tons.

Summary

Salt Well No. 2 at Waterways is 789 feet deep. The gypsum and dolomite occur at a depth of 415 feet, and the pre-Cambrian granite was struck at 785 feet. Several very thin beds of salt, and many lenses of rock salt interspersed in gypsum, anhydrite, and dolomite rocks were encountered, but no beds of pure rock salt occur at this point. A strong flow of salt water, producing 24 gallons of brine per minute, occurs at 666 feet. This brine on analysis was found to have a salinity of 16%, which represents an output of 6.2 tons of salt in 24 hours, or 2,263 tons per year. If cheap fuel were available, this brine would be worth further consideration. The fact that brine of this volume and quality occurs, indicates that there is a considerable amount of rock salt interspersed with these rocks. On the other hand the results of Well No. 2 indicate that the workable beds of rock salt proven in the McMurray well do not extend as far east as Waterways.

PARADIS GAS WELL

It has been the experience of drillers in the Edmonton district to strike small flows of gas when drilling for water. One such occurrence was examined by the writer in October, 1923. A well was drilled by Mr. R. H. Weaver on the farm of Mr. J. Paradis, about 15 miles north of Edmonton, near Duagh, in section 4, township 55, range 23. At a depth of 406 feet a flow of gas was struck which had sufficient pressure to force the water out of the well. For the first 12 hours the water was thrown intermittently about 60 feet in the air. In 36 hours the eruptions were less than 20 feet. The well was later capped, and a small pipe was attached to the top of the pump, carrying the gas about 300 feet from the well, where it burned constantly for several days. Later, the gas flow decreased until it would flow only during pumping operations. This is the condition of the well at the present time (March). The gas burns with a long yellow flame, and is almost odourless. A sample of

gas, taken by the writer, was analyzed by J. A. Kelso, University of Alberta, with the following result:—

Methane	83.2%
Oxygen	3.1%
Nitrogen	13.2%

The oxygen and nitrogen content suggests that there was some air in the sample. A sample free from air would be nearly pure methane.

The water is slightly saline, and the included gas can be lighted in the watering trough at any time. An analysis of the water made at the Industrial Laboratories, University of Alberta, is as follows:—

	Parts per Million	Grains per Gallon
Sodium Chloride	5,700	399
Lime Carbonate	175	12
Magnesia	nil	nil
Sulphates	nil	nil

The above salinity is approximately 0.5%, there being practically nothing but common salt in the sample.

WAINWRIGHT OIL WELL

A new and important chapter in the story of petroleum development in Alberta was begun in November, 1923, when Well No. 2, drilled by the British Petroleums, Ltd., was "brought in." Well No. 2 is situated in section 31, township 45, range 6, west of the 4th meridian, about five miles north of Wainwright, on the south bank of the Battle river, and about 100 miles southeast from Edmonton. This well is located about 200 yards southeast of Well No. 1, which was started in November, 1922, in section 36, township 45, range 7, and was completed in five months as a gas well at a depth of 2,017 feet.

Well No. 2, drilled to 2,036 feet in about six months, was "brought in" by D. O. Credille as a gas and oil well. The oil is reported to come from a seventeen-foot sand between 2,019 and 2,036 feet, which is supposed to represent the basal beds in the Colorado group of rocks.

The writer visited the well soon after it was completed. When the valve was opened, the gas pressure was sufficient to force the oil and gas through about 1,700 feet of water and mud in the well with great force and with a thundering roar. The oil, gas, silt, and water mixture has a light brown color, with occasional splashes of pure oil of a dark brown color. The well has not yet been cleaned of mud and water, so that it is not possible to estimate the quantity of oil, as it is intimately mixed with water and silt. Officials of the company state that although the gasoline content is very low, yet the lubricating fractions represent a large percentage of the whole, and the quality of this lubricant has been pronounced to be excellent. Even though the oil is classed as heavy, the established fact that sands in this horizon are productive warrants the drilling of several wells along the major structure that is known to exist in

this part of the province, and also gives encouragement to those who believe that Alberta will yet become an important petroleum producing province.

The Wainwright field is on the eastern limb of a well defined major geological structure which extends from Birch lake in township 50, ranges 11 and 12, in a southeasterly direction to Misty Hills in township 33, range 4. The distance between these two points is about 110 miles. J. B. Tyrrell, who first examined the geology of this part of Alberta in 1886, described this structure as the "Battle River anticline." Twenty-nine years later detailed field work between Battle river and North Saskatchewan river proved that the structure was not anticlinal, but monoclinal. This major structure was first determined in the field, and described as monoclinal, in 1917 by S. E. Slipper and by the writer. Later field observations by D. B. Dowling, J. S. Stewart and G. Sheppard verified this determination. A monocline is a fold in which the beds are nearly flat on one limb, and with a steeper dip on the other limb. In this case the steeper dip is towards the west, and averages about 25 feet to the mile.

There are indications of terrace-like structure on the west limb in the vicinity of the Viking gas field from which the City of Edmonton is supplied with natural gas. The area of this gas field has been outlined by L. G. Huntley as covering 27 square miles, and probably 40 square miles; and the gas capacity in reserve is estimated at 60,000,000,000 cubic feet. This indicates that this major structure does contain petroliferous material in large quantities.

The Wainwright well on the east limb of the structure has proven that there are also heavy petroleum products. It is reasonable to assume that, since these two extreme products, natural gas and petroleum with heavy gravity, occur in the same major structure, intermediate petroleum products can be expected to occur somewhere in this structure, which covers possibly five or six hundred square miles. There are local structures suitable for oil accumulation within the major structure, and it is in some of these that oil can be expected to occur.

As much of the surface is covered with glacial debris, and rock outcrops are few, the position of the most promising structures can not be outlined until much drilling has been done, and careful records kept of the formations encountered in every well.

At the present time there is no part of Alberta where oil possibilities are more promising than on this major structure briefly described above.

COAL AREAS OF ALBERTA

The need of a map outlining coal areas in Alberta based on geological features has been apparent for some time. Such a map was required for the classification of coals according to their chemical analyses, and also for the marketing of coal where it is advisable to indicate the district from which the coal has been mined.

The Federal Mines Branch and the Scientific and Industrial Research Council of Alberta have been classifying coals according to the provincial mine inspection districts, which were based on geographical, rather than geological, considerations.

The map (Serial No. 6) accompanying this report shows 36 coal areas, which are defined according to the principal coal-bearing formation underlying each area.

The ideas contained in this scheme have been submitted to the Director of the Mines Branch, Ottawa. Much assistance was given in the preparation of this map by the discussion and helpful criticism of Dr. D. B. Dowling, Geological Survey, Ottawa, Mr. R. E. Gilmore, and Mr. J. H. H. Nicolls, of the Fuel Testing Division, Mines Branch, Ottawa.

There are three coal horizons in Alberta from which coal is mined: namely, Kootenay, Lower Montana, and Upper Montana, all of Cretaceous age. The Lower Montana coal horizon occurs in what is known as the *Belly River series* throughout the greater part of Alberta, but which, in the foothills north of the North Saskatchewan river, is called the *Saunders formation* by the Alberta Geological Survey. The Upper Montana coal horizon occurs in a series of strata widely known as the *Edmonton formation*.

A general description of the occurrences and extent of the coal deposits, and their relation to the geology of the province, are given in the First Annual Report on The Mineral Resources of Alberta (pp. 46 and 47). It should not be assumed, however, that coals of an older formation are always of higher grade than those of a newer formation. Proximity to the mountains, and the consequent pressure to which they have been subjected, have frequently had a greater influence on the character of the coals than the effect of mere age. Thus the more westerly coals of the Edmonton formation are of distinctly higher grade than the eastern coals of the Belly River formation.

The map is made on a scale of 30 miles to one inch, and different colors are used to differentiate the areas that are underlain by each of the three coal horizons.

There are 36 coal areas shown on the accompanying map. Ten of these areas include the *Kootenay coal-bearing rocks*, and lie on a line along the eastern face of the Rocky Mountains, parallel to the trend of the mountains. These areas have been named as follows:—

Smoky River*	Panther*
Brule	Cascade
Mountain Park	Highwood*
Nordeg	Oldman*
Clearwater*	Crowsnest

*There are no producing mines in these areas.

The next coal horizon occurs in the *Belly River* or *Saunders formation*, and is represented by 14 areas, as follows:—

Halcourt	Magrath
Prairie Creek*	Lethbridge
Coalspur	Milk River
Saunders	Pakowki
Morley	Taber
Pekisko	Redcliff
Pincher	Brooks

Seven of these areas lie along the eastern side of the Kootenay areas; the other seven extend along the southern boundary and part way up the eastern side of the province. The distribution of these areas along the western and eastern sides of the province is due to the broad synclinal structure, which brings these coal horizons to the surface along the entire eastern boundary of the province almost as far north as the North Saskatchewan river.

The remaining 12 areas shown on this map are bordered by yellow, and include the greater part of the *Edmonton formation* where the coal seams occur close enough to the surface to be mined. These areas are distributed up the centre of the province, and are named as follows:—

Pembina	Big Valley
Edmonton	Carbon
Tofield	Sheerness
Camrose	Drumheller
Castor	Gleichen
Ardley	Champion

Each area is named after some mining centre, town, or geographical feature, occurring within its boundaries, which enables the reader to associate it with a particular part of the province.

In so far as it was possible, three factors were considered in defining the boundaries of the areas: the distribution of the geological formations so far recognized; the positions of mines and prospects; and the character of the coal, as indicated by comparable chemical analyses.

A difference of opinion may rightly arise as to the precise boundaries of any of these areas, and this attempt at classification of coal areas can not be regarded as final.

Since this map was prepared, additional chemical information has been obtained that already suggests some alterations; but these are only of a minor character. There are also a few small prospects, mentioned in the recently published 1923 Mines Branch, Alberta, report, that are not included in the areas defined, but the output from these is very small.

*There are no producing mines in these areas.

It will also be noted that the coal areas shown on the map do not include the whole of the province. Additional areas will be added when the occasion arises; but there are extensive areas in Alberta where there are no coal-bearing strata, or where the coal seams are not of commercial quality, or where the coal seams occur at too great a depth for commercial mining, and such areas are advisedly omitted from classification.

When more is known about the quality of the coal within an area, it may be necessary to subdivide or make sub-areas within that coal area.

The writer would also draw attention to the fact that there may be, and in some places are, lower coal horizons below the one indicated by a color as occurring near to the surface. For example, it is known that there are coal seams in the so-called Belly River series below some of the areas designated as of the Edmonton coal horizon. Should any of the coal seams from a lower horizon be mined within the boundaries of a coal area indicating a younger coal horizon, it will then be necessary to supplement the map data.

Within the mountains, owing to the uneven pressure to which the rocks have been subjected, there are places where the same seam of coal may show marked variation of chemical characteristics within a short distance. It is obviously impossible to include these variations in any workable delimitation of areas.

It is hoped that this areal classification will take the place of the one previously used by E. Stansfield and J. H. H. Nicolls in Bulletin No. 25, Mines Branch, Ottawa, entitled, "Analyses of Canadian Fuels," Part IV., 1918. These areas were based on the provincial mine inspection districts, which include the whole of the province to the twenty-fourth base line. These are geographical rather than geological units, and are not suitable for a classification of Alberta coals, which occur in three distinct geological formations.

THE BITUMINOUS SANDS OF NORTHERN ALBERTA

THEIR SEPARATION AND THEIR UTILIZATION IN ROAD CONSTRUCTION

BY K. A. CLARK

INTRODUCTION

The Third Annual Report contained an account of the development in the laboratory of a method of separating the bitumen and mineral constituents of the bituminous sands, and of the study of the adaptability of the separated bitumen for bituminized earth road construction. The work of 1923 consisted in putting to practical test the methods of these successful laboratory experiments. This report discusses the results obtained in the construction and operation of a plant for the separation of the bitumen from many tons of bituminous sand, and in the use of the supply of bitumen so obtained in the building of a stretch of bituminized earth road on one of the public highways.

THE BITUMINOUS SAND SEPARATION PLANT

The purpose for which the construction of a separation plant was undertaken was to determine whether the operations that had been worked out in the laboratory for separating the bitumen from the bituminous sands were of such a nature that they could be adapted to large scale work. Some approximation of the cost of separation by the proposed method was also desired. A plant of some considerable size was needed for the purpose, and room was required for its erection. A site which met the situation fairly well was found in the basement of the University power plant building. There was plenty of floor space, and steam and electric power connections were at hand. There were several serious drawbacks, however, which set limitations on the design of the plant and caused inconvenience in operation. The height of the basement room was not enough to allow of a plant design which provided a fall from one end of the plant to the other. This feature was responsible for the main difficulties met with in the operation of the plant. It was also a bad arrangement to have to throw tons of bituminous sand into a basement and then lift it all out again as separated bitumen and tailings. These difficulties were not serious enough, however, to materially interfere with the attainment of the purpose of the work. A plant was built which operated smoothly and which successfully separated about eighty-five tons of bituminous sand.

DESCRIPTION OF PLANT

The main features of the separation plant design are shown in the plan and elevation drawings of Fig. 12. At the head of the plant a *treatment box* was provided in which the bituminous sand

to be separated received a preparatory treatment with silicate of soda solution. This box, as well as all the other boxes of the plant, was made of No. 16 gauge sheet metal. It was $10\frac{1}{2}$ feet long, $21\frac{1}{2}$ feet wide, and $4\frac{1}{2}$ feet deep. The general shape of the box can be seen readily from the drawing. A horizontal screw conveyor was fitted into the V-shaped bottom of the box, and an inclined screw conveyor, surrounded by a tube, was placed in the V of the constricted end. The box held three tons of bituminous sand. The expedient of feeding the bituminous sand uphill out of the treatment box to the rest of the plant by means of a screw conveyor on a 45° incline was one that no one wished to endorse. But because of lack of head-room the treatment box could not be raised. Preliminary experiments were run to determine whether a screw conveyor working in a tube would bring up treated bituminous sand. Indications were favorable, so the screw conveyor feed out of the treatment box was adopted. It worked reasonably well in the plant.

The inclined screw conveyor delivered treated bituminous sand to *No. 1 mixing box*. This was a sheet metal vessel, 15 inches square

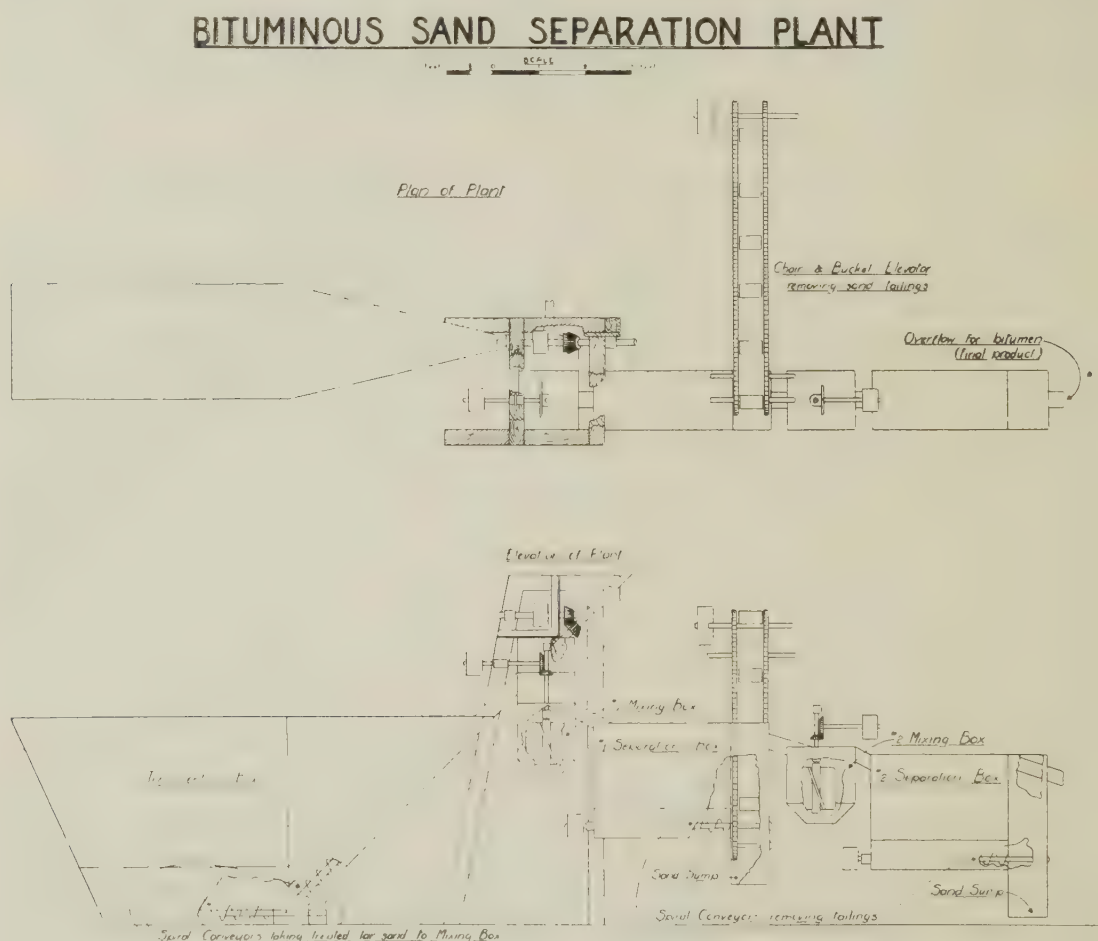


Figure 12.—Diagram of Bituminous Sand Separation Plant.

and about 20 inches deep. A paddle was provided for agitating the water maintained in the box. An overflow pipe connected *No. 1* mixing box with *No. 1 separation box*.

No. 1 separation box was rectangular in construction, 36 inches long, 15 inches wide, and $37\frac{1}{2}$ inches deep. The bottom was V-shaped, and had a screw conveyor fitted into it. At the end of the box, and built as part of it, there was a boot or sand sump,

forming a 10-inch addition to the length of the separation box and extending 10 inches deeper than it. A bucket line was fitted into this boot. Sand tailings sinking through the water contained in the separation box were carried into the boot by the screw conveyor and then picked up by the bucket line.

A No. 2 mixing box and a No. 2 separation box were provided in the plant, and differed very little in design from those already described. No. 2 mixing box had a partition or baffle separating the part of the box where the paddle revolved from the overflow pipe. The purpose of this baffle was to make all the material entering No. 2 mixing box from No. 1 separation box pass downward and underneath the baffle before it could proceed further along the plant. It was intended that the second mixing box should remove more sand from the bitumen concentrate floating off from the first separation box, and it was feared that this bitumen might pass over the surface of the second mixing box without getting properly broken up and agitated. No bucket line was provided for No. 2 separation box. What little sand accumulated in the boot was removed with a hoe.

The water and steam piping for the plant is not shown in the diagram, but it is easily described. Each box was provided with a system of closed steam coils. The condensate in the heating coils ran into a trap, which discharged it intermittently into a tank where its volume could be measured. A steam pressure of about 15 pounds was used. A pipe for introducing water into the plant was brought to Nos. 1 and 2 mixing boxes. These connections were used to give the mixing and separation boxes an initial filling with water, and to replace the continuous loss of water from the system during operation. A water-circulating system from each separation box into its corresponding mixing box was provided by leading a pipe from the lower part of the separation box through a motor-driven centrifugal pump and up into the top of the mixing box. A connection from the discharge side of the pump for No. 2 separation box was brought forward to No. 1 mixing box so that a portion or all of its discharge could be introduced into No. 1 mixing box.

The plant was driven by electrical power. A shaft suspended above the plant from the ceiling, and a countershaft on the floor, allowed of placing pulleys for driving each part. All screw conveyors were turned at a speed of 40 revolutions per minute; the mixing box paddles were run at 100 revolutions per minute; while the bucket line was arranged to travel 20 feet per minute. These speeds gave the plant a throughput of one-half ton of bituminous sand per hour.

A strong framework of 4" by 4" lumber was built to support the various boxes and to carry the bearings, etc. All boxes were surrounded with lumber to lend them support and to act as insulation against the loss of heat. A wooden charging platform was provided at the head of the plant.

OPERATING PROCEDURE

The first operation in the separation is the treatment of the bituminous sand with silicate of soda solution. The function of this

has been discussed in the Third Annual Report (Report No. 8). Suffice it to say now that this treatment brings the bituminous sand into such a state that its bitumen and sand constituents adhere loosely to each other and are readily separated by the later operations. Bituminous sand was brought from the stock pile in wheel barrows, weighed, and thrown through a window opening onto the charging platform above the treatment box. Three tons, approximately, were brought to the plant, and placed in readiness for treatment. A quantity of silicate of soda solution was poured into the empty box. The quantity of solution used was so controlled that it thoroughly soaked the charge, but did not provide any excess. Solutions used varied in strength from $\frac{1}{2}\%$ to 2% by weight of various brands of liquid silicate of soda. The weighed quantity of bituminous sand was thrown into the solution. The treatment box was charged at the close of the day, and the material made ready for the commencement of a run next morning. Steam was then turned into the steam coils of the treatment box, and the charge left to heat up to about 80°C. to 90°C. Various times of heating were tried. On heating, the silicate of soda solution penetrated through every portion of the bituminous sand, and reduced it to a uniformly mushy mass.

The separation of the bitumen from the treated bituminous sand was a continuous operation. The various boxes were filled with water, and the pumps started. The level of the water in the separation boxes was brought to a point a few inches below the overflow pipes, and held there. The steam was turned into the heating coils, and the temperature of the water in the plant brought up to about 85°C. Power was then applied to the moving parts, and the separation process commenced. The screw conveyors in the treatment box lifted treated bituminous sand up to No. 1 mixing box, and dropped it onto a short platform sloping into the water. The stream of water from the pump, entering the top of No. 1 mixing box, washed the bituminous sand into the body of water being agitated by the paddle. The main separation action took place in No. 1 mixing box. The treated bituminous sand, on being introduced into the body of agitated water, dispersed immediately into clean sand grains and small masses of bitumen. Water, with sand and bitumen suspended in it, continually overflowed into No. 1 separation box. This box contained a large body of comparatively quiet water. The sand particles sank to the bottom, while the bitumen floated on the water surface in a frothy layer. The sand from the bottom was carried into the sand sump by the screw conveyor, and was picked up by the bucket line. The bitumen layer accumulated on the water surface until it overflowed through the outlet pipe into No. 2 mixing box. The action sought in No. 2 mixing box was to further reduce the mineral content of the bitumen concentrate. The action of No. 2 separation box was the same as that of No. 1. Bitumen finally flowed through the outlet at the end of the plant, and was collected in suitable vessels.

Several features about the bucket line and the elimination of the sand tailings should be mentioned. The buckets, filled with the very fine, wet, sand tailings, refused to dump. This difficulty

was overcome by directing a jet of hot water into the buckets as they travelled along the horizontal portion of the bucket line over the box in which the sand tailings were collected. This jet was connected to the discharge side of the two centrifugal pumps. The sand tailings box had a false end filled with coarse gravel, which formed a filter column covering the outlet in the bottom of the box. The wet tailings and the water jet introduced a considerable quantity of water into the tailings box. This excess water drained away through the gravel into the outlet pipe leading to the sewer. A considerable amount of bitumen accumulated in the tailings box as a layer floating on the excess water. Although the tailings in the buckets appeared clean, they yielded further bitumen when dropped into the water in the tailings box. This bitumen was skimmed off from time to time and put back into the treatment box.

There was a constant loss of water from the plant, which was balanced by the introduction of fresh water. No automatic control was provided to keep the water levels constant, but the flow was watched and regulated from time to time to maintain the balance against the water lost. The principal losses were due to the water carried in the sand tailings and to the water from the system used to operate the jet for emptying the buckets.

As much data as possible about the separation operation was recorded. Temperatures in the various parts of the plant were noted throughout the runs. Heat used was determined by measuring the volume of condensed steam, and the temperature and volume of hot water introduced into the plant. Power consumption was determined by measuring current used with a watt-meter. Samples of raw bituminous sand, bitumen concentrate from each of the two separation boxes, and sand tailings, were collected for each run, and analysed. Samples of water from the two separation boxes were also collected, and examined for accumulation of silt and sand in the water. Various features about the plant and its mode of operation made it impossible to prepare a balance of materials entering the plant against materials passing out. The treatment box was never completely emptied by the screw conveyors. Consequently, the total amount of bituminous sand passed through the plant in a run could only be approximated. The sand tailings left the plant wet, and it was difficult to get an accurate measure of their dry weight. The bitumen concentrate produced contained emulsified water in varying amounts. Some bitumen separating in the tailings box worked its way through the gravel filter and was lost. No appliance was available for metering the hot water entering the plant. Water leaving the plant was approximated by catching it in pails, and weighing it during an hour period of a run. However, the analyses of the bituminous sand treated, and its approximate weight, analyses of the concentrated bitumen and sand tailings produced, and a measure of the steam condensed and hot water introduced during a run, allowed of a very fair determination of the effectiveness of the separation and of its cost for heat.

DATA

Details of nine consecutive runs for the separation plant are given in Table X. Conditions were deliberately varied, and a wide range of variation was covered in the series of runs. The strength

of silicate of soda solution was varied from 0.8% to 2.0%. The length of time of treating the bituminous sand by heating in contact with the silicate of soda solution was varied from 1 hour to $7\frac{1}{4}$ hours. The amount of fresh water introduced into the plant, and consequently the quantity of dirty water eliminated, was varied from 2,200 pounds to 10,750 pounds per run. A marked difference in the effectiveness of the separation can be noted from the figures in the table. Sand tailings were obtained which retained from $6\frac{1}{2}$ to 2% of bitumen. The bitumen concentrates, free of water, contained from 8 to 12% of mineral matter. It should be understood, in connection with these figures, that no attempt was made to put each run through under optimum conditions; on the contrary, as much sensible variation as possible was aimed at in order to gain knowledge of the effect of the different factors.

The heat consumed in the making of the runs has been calculated and recorded in the table. Water at 15°C . was taken as the start for reckoning heat used. The heat absorbed from the steam condensed was taken as the difference in heat content of steam at 109°C . and water at 100°C . Although the hot water discharged by the steam trap was not actually used, it could have been used to full advantage for the introduction of fresh hot water into the plant. The fresh water actually introduced was return water from the University heating system. Its temperature varied from run to run from 50°C . to 70°C .

Heat consumption has been divided into heat used for treatment and heat used for separation. This is not a very real division, however, since steam was kept in the coils of the treatment box throughout the run as well as during the period before the run, during which the bituminous sand charge was being heated up.

The attempt was made to determine the power consumption of each part of the plant, but the attempt was not rewarded by much success. A watt-meter was put into the electric power circuit, and readings were taken under a variety of conditions of load. It was hoped that, by subtracting readings for various combinations of parts running, the power required by each part could be determined. But the figures varied in such a way that no great reliance can be placed on the figures so calculated. It took $2\frac{3}{4}$ h.p. to run the plant machinery with no load and no water in the various boxes. When the boxes were filled with water, the power used increased to 3 h.p. The extra power required for running bituminous sand through the plant was from 2 to 3 h.p., depending on the way in which material was feeding out of the treatment box. The part of the plant which absorbed the largest share of the total power was the horizontal screw conveyor in the treatment box. It ran buried deep in the bituminous sand, and there was no outlet for the material it moved except in so far as the inclined conveyor took up material. This horizontal conveyor worked hard, and a great deal of its work was to no useful purpose. The inclined conveyor absorbed about $\frac{1}{2}$ h.p. for carrying its load. The conveyors, paddles, and bucket also absorbed about $\frac{1}{2}$ h.p. for handling their load. Another $\frac{1}{2}$ h.p. was used in running the two water pumps.

TABLE X.—RESULTS OF NINE CONSECUTIVE RUNS OF
SEPARATION PLANT

Date of Run.....June, 1923	1	4	5	6	7	8	11	13	14
Weight of Bituminous Sand charge	5,300	5,650	5,500	5,200	5,100	5,050	4,700	5,650	5,500
TREATMENT:									
Duration	7¼	1	2	2¼	2¼	2	2½	3	4½
Steam Condensed	415	167	182	106	227	250	258	273	202
SEPARATION:									
Duration	7	6	5¾	5¾	6½	7¾	6½	6¼	6
Steam Condensed	545	715	536	522	600	637	387	1,183	967
Water Introduced	2,900	2,700	2,700	2,200	2,200	4,400	3,500	10,750	10,000
Silicate of Soda Soln.:									
Wt. per ton of Bituminous Sand	180	240	185	190	200	200	235	195	235
Concentration	1.7	0.8	0.8	1.2	1.7	2.0	1.8	2.0	2.0
Heat Consumption per ton of Bituminous Sand:									
Treatment, 1000's of B.T.U.	163.5	72.4	76	51.5	99	109	121	106	86
Separation, 1000's of B.T.U.	308	342	295	277	315	425	308	593	570
Total	471.5	414.4	371	328.5	414	534	429	699	656

Date of Run.....June, 1923	1	4	5	6	7	8	11	13	14
ANALYSES:									
Bituminous Sand:									
Bitumen	17	....	15	13	14.5	13	12	13.5	14
Sand	83	....	81	82	80.5	80	82	83	82
Water	0	....	4	5	5	7	6	3.5	4
Concentrate from No. 1 Separation Box:									
Bitumen	70.5	....	68.5	65.5	60	63.5	49	62.3	56
Sand	7.5	....	8.5	8.5	9	8.5	11	7.7	9
Water	22	....	23	26	31	28	40	30	35
Concentrate from No. 2 Separation Box:									
Bitumen	66	70	64.5	72.5	61.5	65	55	59	63
Sand	7	8	8.5	7.5	5.5	7	7	7	9
Water	27	22	27	20	33	28	38	34	28
Dry Sand Tailings:									
Bitumen	3.6	6.5	4.5	3.8	....	2.8	2.0	2.0	2.0

REMARKS: "S" Brand silicate of soda used (Philadelphia Quartz Co.); $\text{Na}_2\text{O}:\text{SiO}_2=1:3.86$; 6.4% Na_2O ; 34°Be . Steam supplied to plant at temperature of 109°C . Silicate of soda solution was at 50°C . when placed in treatment box. All percentages are by weight.

An estimate of the cost of heat for the runs recorded in the table can be calculated. The most economical combination of treatment and separation heat requirements was 329,000 B.T.U. per ton of bituminous sand separated; the largest combination was 757,000 B.T.U. The University Power Plant evaporates 1,000 pounds of water to steam at 150 pounds pressure for a total cost (including fuel, labor and overhead) of 45 cents. Using this cost for steam as a basis for calculating heat values, the minimum cost indicated by the runs recorded in Table X. for treatment and separation is 14 cents per ton of bituminous sand, and the maximum cost 32 cents. The average cost for treatment is $4\frac{1}{2}$ cents, and for separation, $16\frac{1}{2}$ cents.

Some approximation of the power costs can also be made. The average length of time for putting through runs of $2\frac{1}{2}$ tons was $6\frac{1}{2}$ hours. It required $2\frac{3}{4}$ h.p. to turn over the machinery of the plant at the proper speed, and another 3 h.p. to take care of the load imposed by running through the bituminous sand. Consequently it required 7 h.p.-hours per ton of bituminous sand to overcome the inertia of the plant, and 8 h.p.-hours to separate the ton of material. Taking the steam requirement per h.p.-hour at the highest value of 35 pounds, and the cost of steam at 45 cents per 1,000 pounds, the cost for power is 11 cents per ton for turning over the plant, and $12\frac{1}{2}$ cents per ton for separating the bituminous sand.

The costs for heat and power for separating a ton of bituminous sand should not be added together in reckoning the total cost. If the power were generated by a steam engine, all the exhaust steam from the engine could be used in the heating coils of the plant and for heating water. The maximum requirement of 35 pounds of steam at 150 pounds pressure, per h.p.-hour, has been allowed in estimating the quantity and cost of steam for power. This quantity of steam would produce the power required and turn steam into the exhaust at the 15 pounds pressure used for passing through the heating coils of the plant. Fifteen h.p.-hours would provide 525 lbs. of exhaust steam per ton of bituminous sand treated. The average heat consumption for the nine runs, per ton of bituminous sand, was 470,000 B.T.U., of which amount 165,000 B.T.U. were represented by 1,320 pounds of water introduced into the plant and brought to the temperature of 85°C . For these runs, the quantity of steam at 15 pounds pressure required for the heating is about 425 pounds. Thus the cost of the power required also covers the cost of the required heat.

It should be emphasized that all estimates of the cost for heat and power for separating the bituminous sand are based on the data obtained during the runs, as actually carried through and recorded in Table X. No account is taken of obvious savings in both heat and power that could be made in a better designed plant and better conducted runs.

The average weight of silicate of soda used per ton of bituminous sand treated was $3\frac{1}{4}$ pounds. Silicate of soda can be bought and brought to Edmonton for $1\frac{1}{4}$ cents per pound. The cost of silicate of soda for separating a ton of bituminous sand is therefore about 4 cents.

A PRACTICAL EXPERIMENT IN BITUMINIZED EARTH ROAD CONSTRUCTION

Previous Annual Reports have discussed the possibilities of bituminized earth road construction as a means of providing a low-priced improved road for prairie conditions, where gravel deposits are lacking. Laboratory experiments in stabilizing various types of Alberta soils by admixture with them of bitumen extracted from the bituminous sands had yielded encouraging results. The next step was to carry the testing to the practical stage of building a piece of road. Such a test was made during the fall of 1923.

The Fort Saskatchewan Trail, at a point beyond the limits of the City of Edmonton, was chosen as the site for the road construction experiment. This site offered most of the advantages sought. The existing road was well drained by side ditches. The soil was of a troublesome sticky clay type. And the Fort Trail is probably the most heavily travelled road leaving Edmonton.

Preliminary examination was made of the soil occurring along the stretch of road to be built, in order to determine its nature and the amount of bitumen that would have to be mixed with it in order to make it stable in presence of moisture. Four samples were collected by digging holes about six inches deep at equal intervals along the centre of the stretch and taking all the soil dug from the holes. These samples were subjected, at the laboratory, to a physical analysis to determine their content of clay, silt, and sand. The results were as follows:—*

Samples	Clay	Silt	Coarse Silt	Sand
1	28%	31%	11%	30%
2	31	25	13	31
3	25	31	13	31
4	25	29	13	33

Test briquettes of bituminized soil were made from each of the four soil samples by incorporating 5% by weight of bitumen from the bituminous sands into the moist soil, moulding in a briquette press, and allowing the briquettes to dry. The dry briquettes were then exposed to an artificial rain created by the spray of a garden hose. The briquettes containing 5% of bitumen went to pieces under the test. Sets of briquettes were then made containing 10% and 15% of bitumen. These briquettes stood the test of the artificial rain satisfactorily.

The bitumen for incorporation into the soil of the road was the crude asphalt extracted from the bituminous sand separated in the plant already discussed. About five tons of asphalt were

*The physical soil analyses were made according to the common method used in soil examination. The soil particles (after the soil sample had been completely dispersed in water) which settled out of suspension in water in 4 minutes or less, but which were retained by a 200-mesh sieve, were classed as "sand". Particles settling from water in 4 minutes and passing a 200-mesh sieve were classed as "coarse silt". Particles remaining in suspension in water for 4 minutes, but thrown down during 8 minutes of centrifuging at 1,000 r.p.m. were classed as "silt". The remaining soil particles, not thrown down by centrifuging, were classed as "clay."

available for the road test. Many of the typical soils of the province can be satisfactorily stabilized by the incorporation of 5% of bitumen. A treatment of soil to a depth of 6 inches has been the general plan for a practical road test. But since the soil at the site chosen on the Fort Trail required 10% of bitumen, and since a stretch of road 500 feet long seemed as short as was at all desirable, it was obvious that a reduction in depth of treatment from the original plan would have to be made. The treating to a depth of 2 inches of the 500 feet for a width of 14 feet, incorporating 10% of bitumen, called for nearly six tons of asphalt. It was decided to attempt to treat to a depth of 3 inches, making the bitumen content more at the top of the treated layer than at the bottom.

The construction of the road was a fairly simple operation. The surface of the road was loosened for a width of 14 feet by breaking plow. The road was very dry, and the top soil came out in such hard chunks that there seemed no chance of breaking them down and getting the asphalt into them. Since the roadway had an excessive crown, it was decided to remove the lumps and reduce the level of the centre of the road. The soil below the top hard shell was moist, and pulverized easily. About 3 inches of loosened soil was secured. The asphalt was heated in a kettle provided with steam coils. Since the asphalt, as produced by the bituminous sand separation plant, contained a large amount of emulsified water, it was feared that a direct-fired kettle would cause frothing of the asphalt and lead to trouble. When sufficiently hot to pour, the asphalt was drawn into pouring kettles and spread by hand on the surface of the loosened soil in a thin layer. Approximately one ton of asphalt was used in spreading an application over the entire stretch of 500 feet. While the spreading was being done, a disc harrow worked up and down the road, and cultivated the asphalt into the moist soil. Four applications of asphalt were applied. The cultivating of the bitumen into the loosened surface of the roadway by the disc harrow is illustrated in Figure 13. The loose, bituminized soil was then rolled down by a small gasoline road roller. Finally, a fifth application of asphalt was spread on the rolled surface and covered with a sprinkling of sand.

It was to be expected that the first attempt at bituminized road construction would be faulty in certain respects, and that much room for improvement would be obvious. It is an easy matter to plan to treat a certain depth of soil, but not so easy to carry out the plan in practise. It was found that the plowing of the road reached much deeper in some places than in others according as the hardness of the soil and its texture varied. It is necessary for the easy incorporation of the bitumen into the soil that the soil be moist. The equipment provided for the heating of the asphalt and the spreading of it was so slow that it took a day for each of the five applications. A week-end came in the midst of the process of spreading and cultivating in the asphalt. The weather was warm and windy. The result was that the soil dried almost completely during the many days over which the application of the asphalt lasted, and a satisfactory incorporation of bitumen with soil was not secured. Finally, since it was the practical service test of bituminized earth as a road surface that was sought, no special

care was taken to produce a road with a uniform cross section and predetermined grade. As a result, the final road had not a finished appearance. However, these difficulties and defects could be overcome by more skill and experience in carrying out the various



Figure 13.—Discing Bitumen into Earth Road

construction operations, the use of adequate equipment for heating and applying the asphalt quickly, and by laying down and following proper specifications for building a proper road grade.

COSTS

The actual expenditures for the road construction experiment will serve as some indication of the cost at which bituminized earth road construction can be made. They are as follows:—

Cost of providing a detour and making barricades.....	\$ 50.00
Hauling material and equipment to and from job.....	96.00
Jitney service to take men to town for meals.....	63.00
(Jitney man also maintained lights on barricades after construction was over and road was drying.)	
Two men, two teams, wagons, slips, etc.....	311.00
Fireman	80.00
Rent on portable steam boiler	15.00
Rent on gasoline road roller	32.00
5 tons asphalt at \$30 per ton*	150.00
10% of cost of heating kettle and disc harrow.....	15.00
	<hr/>
	\$812.00

*The cost of the asphalt used has been arbitrarily placed at \$30 per ton, which was the price, approximately, of pavement asphalt in Edmonton. It is not possible, yet, to give a commercial price for asphalt from the bituminous sands.

The cost of an experiment, especially a first experiment, is always high. Further, the cost of a small job is not a fair basis for reckoning the cost of a similar but much larger one. Finally, the labor charges in the expense account are exorbitantly high. Wages for two men and teams, and for a fireman, were paid during five or six days while asphalt was being heated, when, with proper facilities, all that was accomplished in those days could have been accomplished in one day.



Figure 14.—Untreated Road After Rain.

The workmen left the road on October 17th. A rain during the night of the 15th had wet the bituminized soil before final rolling and the placing of the carpet of bitumen and sand on the surface. The barricades were left up until the 23rd to give the



Figure 15.—Treated Road After Rain.

base a chance to dry and harden. It rained again on the 22nd and 23rd. A man went out on the morning of the 23rd, and found the clay roads on either side of the bituminized stretch soft and sticky. Autos were skidding about badly. The experimental stretch, however, seemed hard and unaffected by the wet weather. The bar-the condition of the clay road adjacent to the treated surface after rades were taken down, and traffic has passed over it since. No deterioration was apparent up to the time that snow covered the roads. Heavy grain wagons, tractors, and the like, made marks in the top bituminous carpet, but did not disturb the road bed. Autos quickly ironed out the marks left by the heavy vehicles. It was not expected that traffic would have any destructive action on the road so long as dry weather prevailed. The real test will come during the rainy season of 1924. However, it is encouraging to find no gross defects appearing in the road during the time it has already been exposed to traffic.

Since the preceding paragraphs were written, there has been opportunity to observe the behaviour of the experimental road during wet weather. The photographs reproduced in Figures 14 and 15 were taken on May 26th, 1924, after a wet week end, during which slightly more than one inch of rain fell. Figure 14 shows the rain and traffic had had their effect. The treated road can be seen in the background. Figure 15 shows the surface of the bituminized road, unaffected by the rain and traffic, though strewn with mud from the wheels of passing autos.

CONCLUSION

Two practical experiments carried through during the year have been gratifying and encouraging in their results. The bituminous sand separation plant demonstrated the soundness of the preliminary laboratory work on which its design was based, and indications are that a commercially feasible separation process has been evolved. The attempt at practical construction of bituminized roads has also carried the efforts of the Industrial Research Department to work out a serviceable type of prairie rural road to a practical stage. Plans are being made for the coming year to carry out further service tests along both these lines of investigation.

ACKNOWLEDGMENTS

The Industrial Research Department wishes to express appreciation to those that have given assistance in carrying through the work of the year on road materials problems. The Philadelphia Quartz Company took great interest in the separation plant operations, and supplied free of charge four one-hundred pound drums of four brands of silicate of soda. The Department of Public Works of the province co-operated on all matters in connection with the building of the experimental road concerning which its help was asked. The City of Edmonton Engineering Department provided a portable steam boiler for heating the asphalt kettle, and a grader for trimming up the shoulders of the road. The Crown Paving Company went to considerable trouble to arrange matters so that its small gasoline roller could be released for a few days for the experimental road work.

FOREST PRODUCTS OF ALBERTA: MINE TIMBER

By R. S. L. WILSON,

Professor of Civil Engineering, University of Alberta

QUESTIONNAIRE

The following questions were submitted to coal mine operators in every large producing mining district of the province. Replies indicate the range of practice.

QUESTION

1. What are your purchase specifications for mine timber?

2. What species of woods do you use, and how much of each?

3. From what forest area is each kind obtained?

4. At what time of the year is the cutting done?

5. Do you use any timber made from fire-killed trees? If you do, what limitations do you make on the time of cutting after fire-killing?

6. Do you use timbers peeled, or unpeeled, or both. If peeled, to what extent does peeling affect the cost of placing underground?

7. Do you use green or air-dried timber?

8. If you use air-dried timber, what is the range of seasoning period?

9. What is the purchase cost of timber, f.o.b. mine?

10. What portion of the cost is railway freight rates?

REPLIES

Sizes range from 4" diameter upwards. Condition usually specified: "must be sound"; sometimes "dry", sometimes "green".

Fir, jackpine, spruce, tamarac, mountain fir, western pine, poplar. Quantities used of each species depend largely upon the location of the mining district.

Crowsnest Mountain, south-western B.C., Banff Park, Clearwater Forest, northern Alberta.

"All year"; "mostly summer"; "mostly winter".

Some operators will not have it; some others use "practically all fire-killed". Time of cutting, after killing, runs as high as ten years.

Fire-killed timber, when used, is generally preferred without bark. In very few cases is peeling done as a part of the preparation of the timber.

Both are used extensively; air-dried timber includes fire-killed.

6 to 18 months; some of the fire-killed for several years.

1½ cents per lineal foot and up.

Up to 50% of the cost, delivered.

QUESTION

REPLIES

11. How soon after placing underground does fungus growth become noticeable?

- (a) In still air.
- (b) In intake air currents.
- (c) In return air currents.

(a) 1 month to 2 years; "fir timber green peeled never gets fungus"; "almost immediately after placing"; "depends on moisture condition"; "no records".

(b) "5 years"; "several years"; "timber fails before rot appears"; "not at all"; "no records".

(c) "3 months"; "15 to 24 months"; "fungus particularly bad in returns, appears in 6 months and 1 year is life of timber, in rooms does not rot so fast"; "3 years"; "none"; "no records".

12. If a method can be found for extending the life and maintaining the strength of (say) entry timbers, what quantity of annual consumption of timber would be affected? (It is assumed that room timbers have a sufficiently long life.)

Some mines would not be affected; some others would be affected to the extent of 75% of the timber used at those mines.

13. What lagging do you use?

"Dry mill slabs"; "small left-over tops"; "broken props"; "old timbers split", etc.

14. What sawn timber do you use for booms, caps, posts, etc.?

Most of the mines reporting use none.

15. What kind and size of timber do you use for ties? Are they hewn or sawn?

"Standard railway ties"; tamarac, spruce, and fir, hewn; old props, hewn and sawn; "spruce and jackpine sawn"; 4" to 6" faces; 4'6" to 6' lengths.

A detailed analysis of the replies shows that, in the ten mining areas considered:—

Fir	is used in	four	areas
"Jackpine"	" " "	seven	"
Spruce	" " "	eight	"
Tamarac	" " "	six	"
Western Pine	" " "	one	"

It appears that "jackpine", spruce, and tamarac are the three species principally used. Of these, there is considerable information available as to the structural properties of spruce; a little less, perhaps, as to tamarac; and very little indeed of "jackpine". It is likely, too, that of the three species "jackpine" is used to the greatest extent.

No distinction is made between jackpine and lodgepole pine in the replies to the questionnaire. Much of the reported jackpine is lodgepole pine.

EXPERIMENTAL WORK

From the variety of replies respecting time of cutting, usage of fire-killed timber, practice with respect to peeling and seasoning, and effects of fungus, it is apparent that practice is diversified to

the greatest possible extent. After consideration of these facts, a preliminary experimental programme was decided upon, in which lodgepole pine was selected for a first test. Attempts will be made to determine the effects of variations of the following factors:—moisture content, or seasoning period; peeling; underground humidity, temperature, and air circulation; period of time in service; bending and crushing loads. Test pieces have been placed at one mine in ordinary storage piles on the surface, and in three locations underground. The underground locations were selected, one in still air, one in return air, and one in intake air. Half the test pieces were peeled green. All the timber was cut from living trees in December, 1923. The structural tests are being made in the laboratories at the University of Alberta.

LIST OF PUBLICATIONS
OF
THE SCIENTIFIC AND INDUSTRIAL RESEARCH
COUNCIL OF ALBERTA.

ANNUAL REPORTS OF COUNCIL

Report No. 3 (for the calendar year 1920); pp. 36. **Price 5 cents.**

Report No. 5 (for the calendar year 1921); pp. 86. **Price 35 cents.**

Report No. 8 (for the calendar year 1922); pp. 64. **Price 35 cents.**

Report No. 10 (1923); pp. 76.—Reviews the work done during 1923 under the auspices of the Research Council. This includes—the air-drying, analysis, screening, storage, and briquetting of Alberta coals, also their use in domestic heaters, and their combustion for the generation of power; a geological reconnaissance in Alberta, including a survey of the foothills belt between the North Saskatchewan and McLeod rivers; notes on salt well at Waterways, and oil well at Wainwright; the separation of bitumen from the bituminous sands of Northern Alberta and its use in road construction; the study of Alberta trees for use as mine timbers. The report also contains a 4-colour map (Serial No. 6) showing the coal areas of the province. **Price 50 cents. Map only, 15 cents.**

REPORTS ON THE MINERAL RESOURCES OF ALBERTA

By Dr. J. A. Allan, Professor of Geology, University of Alberta.

Report No. 1 (for the calendar year 1919); pp. 104.—A summary of information collected with regard to the mineral resources of Alberta. **Price 10 cents.**

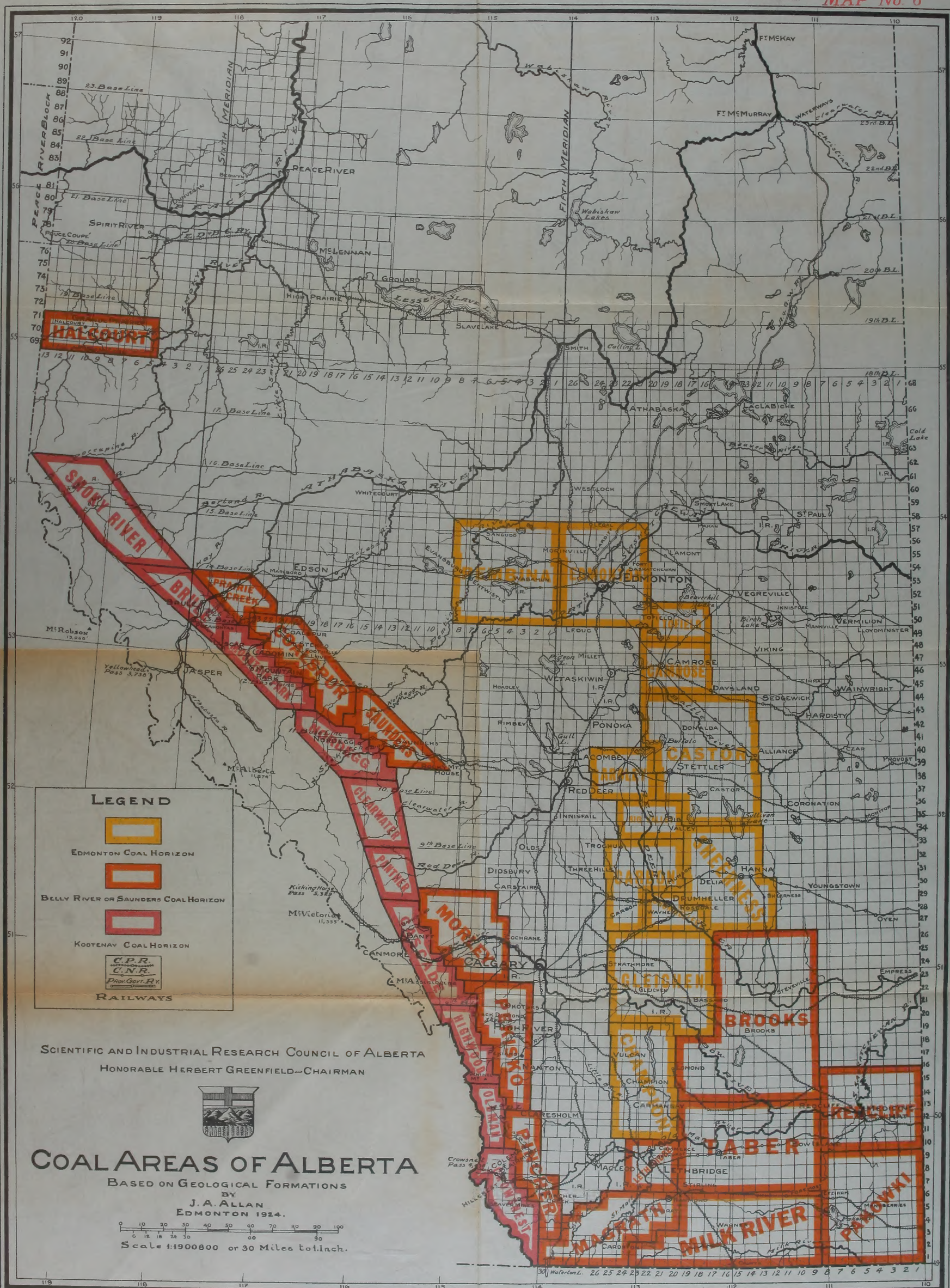
Report No. 2 (for the calendar year 1920); pp. 138+14.—Supplements the information contained in Report No. 1. **Price 25 cents.**

Report No. 4 (for the calendar year 1921); GEOLOGY OF THE DRUMHELLER COAL FIELD, ALBERTA; pp. 72, and 6-colour map (Serial No. 1). **Price \$1.00.**

Report No. 6 (Field work in 1922, Pt. I), GEOLOGY OF THE SAUNDERS CREEK AND NORDEGG COAL BASINS, ALBERTA, by J. A. Allan and R. L. Rutherford; pp. 76, and 2-colour map (Serial No. 2). A preliminary report on the stratigraphy of the coal measures mined along the Brazeau Branch of the Canadian National Railways. **Price 50 cents.**

Report No. 7 (Field work in 1922, Pt. II), AN OCCURRENCE OF IRON ON THE NORTH SHORE OF LAKE ATHABASKA, by J. A. Allan and A. E. Cameron; pp. 40, two maps (Serial Nos. 3 & 4). **Price 25 cents.**

Report No. 9 (Field work in 1923), GEOLOGY ALONG BLACKSTONE, BRAZEAU AND PEMBINA RIVERS IN THE FOOTHILLS BELT, ALBERTA, by J. A. Allan and R. L. Rutherford; pp. 48, and 6-colour map (Serial No. 5), 2 miles to 1 inch. Continuation of the field work in the area described in Report No. 6. The stratigraphy, especially of the coal-bearing horizons, was mapped north-west from Saunders Creek and Nordegg to Coalspur and Cadomin. **Price 75 cents.**



LEGEND



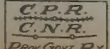
EDMONTON COAL HORIZON



BELLY RIVER OR SAUNDERS COAL HORIZON



KOOTENAY COAL HORIZON



RAILWAYS

SCIENTIFIC AND INDUSTRIAL RESEARCH COUNCIL OF ALBERTA
HONORABLE HERBERT GREENFIELD—CHAIRMAN



COAL AREAS OF ALBERTA

BASED ON GEOLOGICAL FORMATIONS

BY
J.A. ALLAN
EDMONTON 1924.

Scale 1:1900800 or 30 Miles to 1 inch.

